DRILLING
AND PRODUCTION

PIPE LINE

REFINING
NATURAL GASOLINE

TOUGH

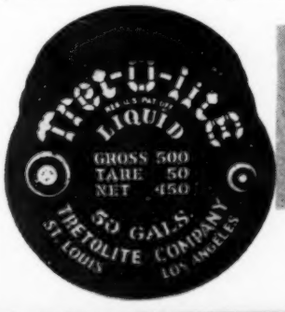
. . . On the tough ones, Tret-O-lite's service and research background proves its true worth. When a producer is wrestling with an "untreatable" emulsion, the Tret-O-lite service representative really can demonstrate what we mean by Tret-O-lite *Service*. If you have an emulsion problem, get in touch with your Tret-O-lite representative for the best in dehydration.

TRETOLITE COMPANY

Manufacturing Chemists

WEBSTER GROVES, ST. LOUIS COUNTY, MO. • LOS ANGELES, CAL.

...n problems other than oil field often arise. In *any* ...m relative to demulsification, call on Tret-O-lite.



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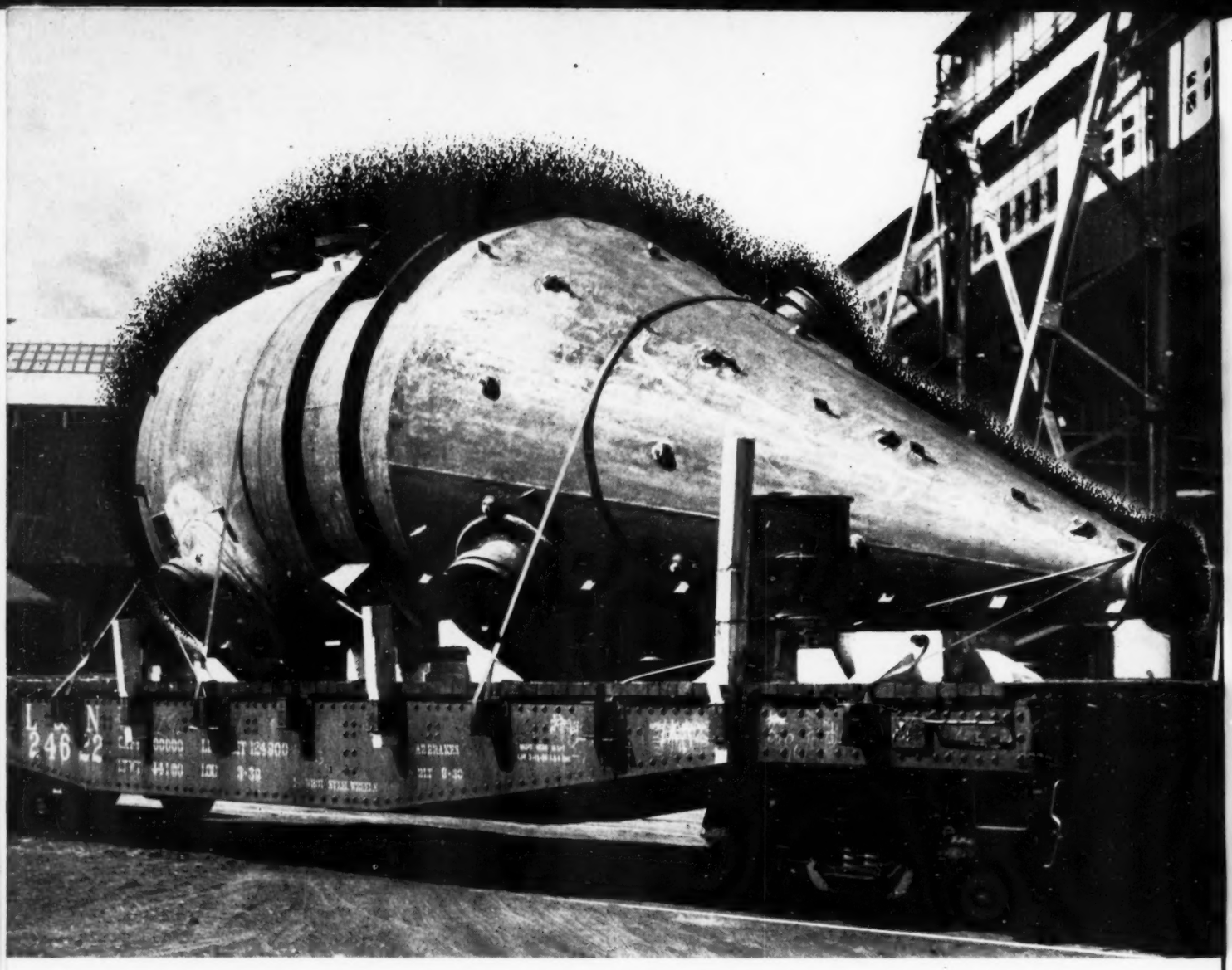

Pressure Vessels...

VITAL LINK IN THE PRODUCTION OF SYNTHETIC RUBBER

NO, this is not a giant anteater, but a welded steel pressure vessel fabricated at our Birmingham plant to meet specific requirements at a refinery.

Vessels such as this are common sights wherever synthetic chemicals, butadiene, high octane gasoline, toluene and other essential wartime products are produced. Fractionating columns, stripper towers, reaction chambers, flash towers, stabilizing columns are a few of the other type of vessels needed today throughout the petroleum industry to help speed the war effort.

The designing and fabricating of pressure vessels is an old story at our plants. If governing specifications call for radiographing and stress-relieving to insure maximum strength and long life, our Birmingham plant has complete facilities for this specialized work. Careful inspection insures units that will serve with maximum efficiency.

If welded steel pressure vessels can aid you in meeting your production schedules, we invite your inquiry.

•

The unit shown is being shipped to one of the nation's large refineries. It is 8½ ft. in diam. and is 27 ft. 1 in. in length, and was both stress-relieved and x-rayed.

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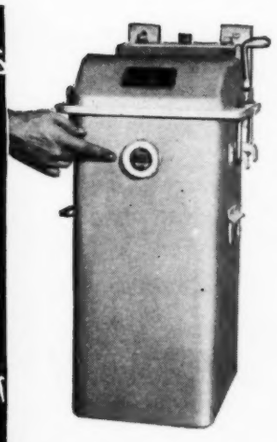
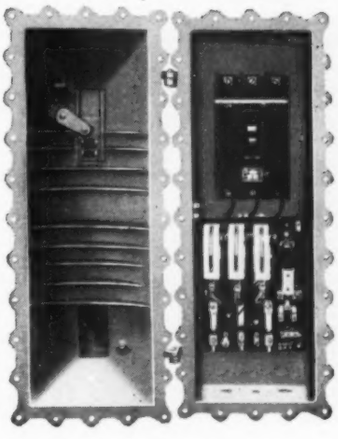
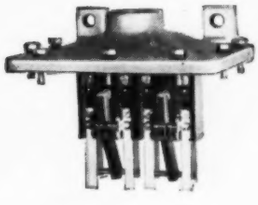


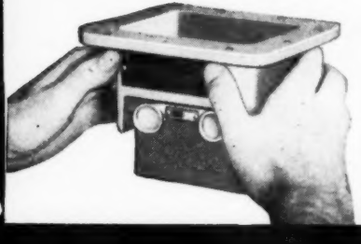
● Standard magnetic starter enclosed in cast-iron case for Class 1, Group D, application.

● Oil-immersed combination starter for Class 1, Group D, locations. All contacts are at least 6 inches under oil. Easy-to-read indicator provides safety check on oil level.



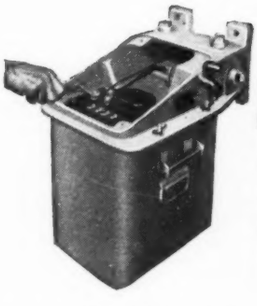


● Air-break combination starter—combining both a circuit breaker and a starter in one unit—for Class 1, Group D, locations. Complete unit is enclosed in a sturdy, cast-iron case.



● Oil-immersed, push-button station for both corrosive and hazardous-gas locations. All contacts are under oil, and entire unit is enclosed in cast-iron case.

● New high-voltage combination starter for 2300- and 4000-volt motors. Contactors are immersed in oil to prevent corrosion.



● Standard oil-immersed combination starter for corrosive locations. New, sealed-off head protects cable and terminals from oil fumes.

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● Readily available standards save hours of engineering time; conserve critical material; can be delivered faster.

No matter what your hazard is—explosive gases, dust, or corrosive vapors—up to 1000 hp, there is a ready-made answer to it in the complete line of standard General Electric controls. And remember these are standard because they have met the test of reliable, on-the-job operation.

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May, 1943

THE Petroleum Engineer

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NOTE: Strict government censorship makes it necessary to omit definite locations of refineries, pipe lines, etc., from editorial matter.

MEMBER A. B. C.—A. B. P. (The articles in *The Petroleum Engineer* are indexed in the *Industrial Arts Index*, New York, N.

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LAST YEAR'S BONDS GOT US STARTED

THIS YEAR'S BONDS

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★ Last year saw nearly 30,000,000 workers voluntarily buying War Bonds through some 175,000 Pay-Roll Savings Plans. And buying these War Bonds at an average rate of practically 10% of their gross pay!

This year we've got to top *all* these figures—and top them handsomely! For the swiftly accelerated purchase of War Bonds is one of the greatest services we can render to our country . . . and to our own sons . . . and our neighbors' sons. Through the mounting purchase of War Bonds we forge a more potent weapon of victory, and build stronger bulwarks for the preservation of the American way of life.

"But there's a Pay-Roll Savings Plan already running in my plant."

Sure, there is—but how long is it since *you've* done anything about it? These plans won't run without winding, any more than your watch! Check up on it today. If it doesn't show substantially more than 10% of your plant's pay-roll going into War Bonds, it needs winding!

And you're the man to wind it! Organize a vigorous drive. In just 6 days, a large airplane manufacturer increased his plant's showing from 35% of employees and 2½% of pay-roll, to 98% of employees and 12% of pay-roll. A large West Coast shipyard keeps participation jacked up to 14% of pay-roll! You can do as well, or better.

By so doing, you help your nation, you help your workers, and you also help yourself. In plant after plant, the successful working out of a Pay-Roll Savings Plan has given labor and management a common interest and a common goal. Company spirit soars. Minor misunderstandings and disputes head downward, and production swings up.

War Bonds will help us win the war, and help close the inflationary gap. And they won't stop working when victory comes! On the contrary—they will furnish a reservoir of purchasing power to help American business re-establish itself in the markets of peace. *Remember, the bond charts of today are the sales curves of tomorrow!*

You've done your bit Now do your best!

THIS SPACE IS A CONTRIBUTION TO AMERICA'S ALL-OUT WAR EFFORT BY

THE PETROLEUM ENGINEER

The Course of Oil

WAR'S IMPACT ON REFINING

The impact of this war upon the oil industry has brought about a change in refining operations in less than two years that would have taken more than ten in normal times. Out of the laboratory to huge-scale production of many products has occurred, with an expenditure of over a billion dollars in construction to produce the essential war materials for ultimate victory.

In considering the many processes involved in producing 100-octane gasoline, new lubricating oils, aromatics such as toluene for T.N.T., cumene for aviation gasoline, butadiene, ethylbenzene and styrene for synthetic rubber, phenols for plastics, and a host of chemical derivatives, more has been learned about the actual chemistry of petroleum and the production of useful high-efficiency products than was thought possible in so short a time. The new processes are here to stay for they give products that have the quality the postwar period will demand.

The refining industry is headed all-out on a chemical basis that will profoundly affect prewar refining practices and products.

Every refiner, wherever practicable, should produce products that are used in the war effort, for the hydrocarbons demanded by war will become basic materials in the coming peace period. There are many processes available in one form or another that fit into the war effort. Catalytic cracking has many ramifications; it produces high-octane aviation or motor gasolines; by adding hydrogen during the catalytic reaction (hydroforming), aromatics are made, such as toluene, xylenes, etc., from naphthas. Catalytic polymerization yields codimers and *iso*-octenes produced from olefins obtained in both thermal and catalytic cracking and dehydrogenation, as well as manufacturing synthetic rubber from butadiene and styrene. Alkylation has been a useful tool not only for the formation of alyllate for aviation gasoline, but also cumene. It has provided the basic process whereby the ethylbenzene can be synthesized for the production of styrene, an important ingredient in synthetic rubber manufacture. Isomerization and dehydrogenation are also important in the aviation gasoline and synthetic rubber programs, for they provide *iso*-butane and olefins for the alkylation reaction. In addition to providing these necessary materials, they are basic reactions of limitless value for making further use of petroleum hydrocarbons after the war is over.

The high-speed, high-temperature aviation engines call for newer and better lubricating oils, which the oil industry has been supplying through the use of solvent extractions, polymerization of olefins and synthetic compounds, such as additives. This tremendously important line of development has not caught the public eye as 100-octane aviation gasoline has, yet its importance cannot be over-rated.

The chemist and chemical enginer have played a profound role in all these developments with some of the most outstanding work resting in the synthesis of many single pure hydrocarbons and blending them to produce the superb aviation gasolines, lubricants, synthetic rubbers, and plastics. Tailored lubricating oils are giving better service to engines operating under more severe conditions than ever before. The new aviation gasolines and lubricants will be peace-time commodities available at low price levels. Automobile engines of lighter weight and greater power output can be designed and produced. Some developments of the airplane industry, such as supercharging of the engines, direct gasoline injection, sealed-in cooling systems, or air-cooled engines may be features incorporated in the future automobile, where the engines are in back of the car. These new engines with enormous power output for automobiles will be midgets compared to the old giants. When the peace comes, there probably will be two grades of automobile gasoline, one of about 75-octane for the old cars, and 100-octane for the new ones.

Great as the demand has been on the oil industry of the United States for the war effort, the future demand will be far greater for the reason that many of the refining and oil-producing centers of the world have been wrecked due to the war. These must be rebuilt, and it may well take several years before they are completely rehabilitated, at a cost of several billion dollars. Then they will operate with all the new processes available and competition will be sharper and keener than ever experienced before in the history of the oil industry.

Gustav Egloff

BEWARE of Wire Rope "Gremlins"

GREMLINS—those sly imps who delight in bedeviling our flying forces—will also get your wire rope if you don't watch out.

The way to combat these little trouble-makers is to give your wire rope constant and proper care. Be on the alert at all times. *Guard especially against the following conditions, which are common causes of premature wire rope failures:*

1. **Improper or insufficient lubrication**
2. **Using wire rope of incorrect size, construction or grade**
3. **Improper selection of sheaves**
4. **Improper care of sheaves**
5. **Sheaves out of line**
6. **An inadequate factor of safety**
7. **An excessive fleet angle**
8. **Sudden jerks or pulls**
9. **Kinking**

The importance of using all means and methods of increasing wire rope efficiency—thereby saving steel for other vital purposes — cannot be over-emphasized. Our experienced Engineering Department is at the service of all wire rope users. Feel free to write us about any wire rope problem which may be giving you trouble.

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Highlights IN OILDOM

Oil Price Hike Denied; Subsidy Suggested

When Price Administrator Prentiss Brown denied Petroleum Administrator Ickes' request for a general increase in crude oil prices averaging 35 cents a bbl., and proposed instead a government subsidy for the drilling of wildcat wells, he met with the united opposition of oil-industry members who look upon the suggestion as an encroachment upon their private initiative.

In denying the request for a price increase Brown said he acted in accordance with the President's hold-the-line order. He stated, however, that greater incentives might be extended to promote exploration for oil. Ickes, in asking for higher crude oil prices, said he sought to stimulate new discoveries, to encourage the use of secondary recovery operations, and to prolong the life of higher cost, or stripper well, production.

Brown stated the increase recommended by Ickes would amount to approximately $500,000,000 annually based on present production. He proposed that in lieu of a price increase the government participate in financing the drilling of wildcat wells.

He stated that the government outlay for drilling 4500 wildcat wells would be less than $150,000,000. The government, under the plan, would supply capital through existing banking facilities to operators for wildcat drilling. In return, the government would receive a one-fourth interest in any well proving to be a commercial producer. If the well was a dry hole any obligation in connection with funds so advanced would be discharged.

Oil Royalty to Government Reduced

Regulations that in some instances would make possible a government reward of more than 100 percent for the discovery and development of new sources of petroleum for the war program, have been put into effect by the General Land Office, it is announced by Secretary of the Interior Harold F. Ickes.

Designed to effect an increase in prospecting for new sources of petroleum, in accordance with provisions of the O'Mahoney Act of December 24, 1942, the regulations establish a flat rate of 12½ percent for 10 years following date of discovery—if discovery is made during the period of the national emergency—in the amount of royalty to be paid the United States for production from a new field or deposit on lands leased from the Government.

Prior to the enactment of the legislation, the royalties paid the Government for the production of petroleum ranged from 12½ to 32 percent, dependent upon the amount of the petroleum produced from the wells. By setting the limit at 12½ percent for the next 10 years for production from a new field or deposit, the regulations afford opportunity for increased profits more than double those under the previous maximum royalty payments required.

Under the regulations, a discovery of oil or gas within the area of any geologic trap in which no discovery theretofore had been made shall be deemed to constitute a discovery of a new oil or gas field within the meaning of the act, and the benefits of the act shall apply to the lease upon which a discovery of a new field or deposit has been made.

In conformity with the intent of Congress to encourage the discovery of new reserves of oil and gas, the new royalty rate is extended by the regulations to all leases committed to and included in an approved unit agreement upon a determination by the Secretary of the Interior that a discovery has been made in a unitized sand or zone of a new oil or gas field or deposit anywhere within the unit area.

The law does not apply to discoveries made prior to the enactment of the legislation, nor to leases carrying a royalty of less than 12½ percent.

To receive the royalty benefits on a new discovery, application must be submitted to the appropriate district headquarters of the General Land Office and to the appropriate federal oil and gas supervisor.

The determination, in any case, regarding whether a new field or deposit has been discovered and the effective date thereof will be made by the Secretary of the Interior after a report has been submitted by the geological survey.

Lower Accident Rate

Annual summary of injuries in the petroleum industry for 1942 reveals lower frequency and severity rates than for 1941 despite the acceleration of the war effort and the confusion of war-time conditions. American Petroleum Institute Department of Accident Prevention reported a 9 percent reduction in severity and a slight reduction in frequency. Many industries have had an upward trend in accident rates, indicating a noteworthy caution on the part of the oil industry.

Salt Water Disposal Bill Dead

Legislation to solidify the Texas Railroad Commission's efforts to force reinjection of salt water into East Texas oil wells, under attack in the courts, died without action being taken at the current session of the legislature.

The commission instituted a water-oil ratio order in East Texas limiting the number of barrels of water that may be produced with each barrel of oil and a suit is pending in the appeals court challenging the body's power to make and enforce such a ruling. Meanwhile Representative Goodman of Fort Worth, at the commission's request, had introduced a bill to authorize specifically such action. Goodman apparently waited too long to ask committee consideration of the bill. It was scheduled before the House Oil and Gas Committee but, with witnesses awaiting an opportunity to testify, the committee could not obtain a quorum. The author of the bill, after the scheduled hearing, said he would not push it further.

Ohio Joins Oil Compact

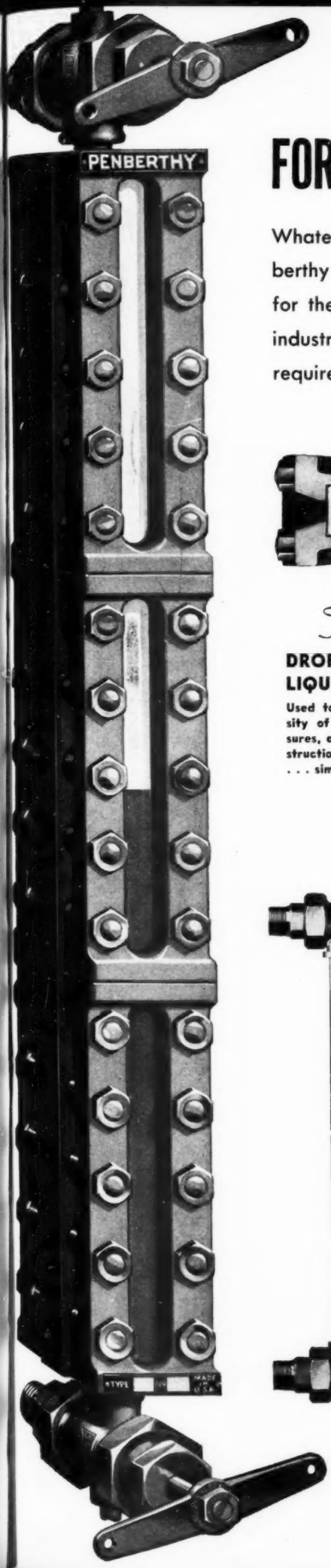
The Interstate Oil Compact Commission received notice early this month that Ohio would join the body, increasing to thirteen the number of member states. Charles Orr, compact commission secretary, received notification that the Ohio legislature had passed a resolution authorizing the state to join. At the time of this notification the resolution awaited the signature of Governor John Bricker, but as the governor had been instrumental in having the legislation written, his signature was believed certain.

State Rule for Hugoton Gas Field

The Oklahoma Corporation Commission, on May 5, signed a conservation order for the Hugoton gas field in the Panhandle area of the state. Chairman Reford Bond and Vice-Chairman Ray O. Weems signed the order, but W. J. Armstrong declined.

The order fixes 640 acres as a drainage unit and provides that the ability to deliver the gas shall be a factor in the amount each well will be allowed to produce.

Weems said that although the order followed the Kansas formula for proration on the Kansas part of the two-state field, there was nothing specific in the order providing that Oklahoma should coöperate with Kansas in enforcing the order.



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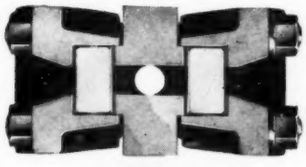

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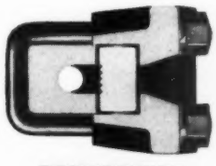

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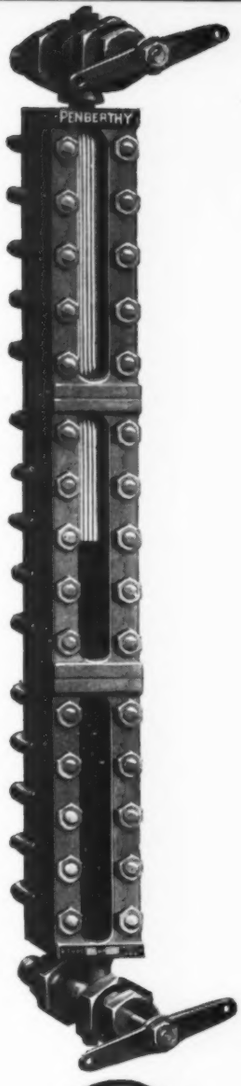

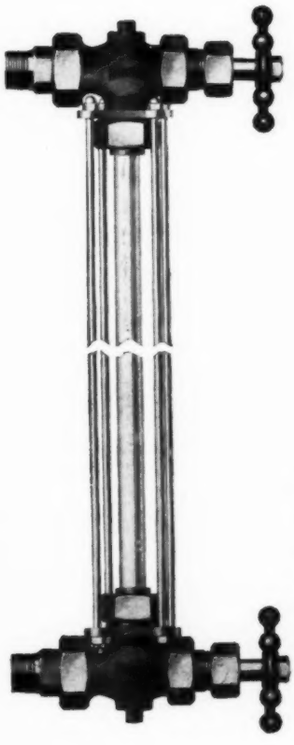

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Water shows black—steam shows white. U-Bolt construction is strongest and simplest to service. Glass replaced by simply removing nuts on face of gage . . . unnecessary to work between gage and boiler.

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MAJOR *Refining* ACTIVITIES

OPERATION of the new production unit at the Point Breeze refinery of the Atlantic Refining Company is now on a 24-hr. basis and thousands of gallons of high-octane aviation gasoline are being made available for the war effort. Announcement of the successful tests and the regular schedule were made by E. J. Henry, vice-president and general manager of refineries of the Atlantic organization.

The entire system of the refining company has produced huge volumes of modern aviation gasoline in the last year and this allows a substantial increase. Although production figures are not available to the public an idea of the scale of the new operations is given by the statement that more than 20,000 gal. of hydrocarbons and catalyst per minute are circulated through the system.

It is said that the new unit marks another forward step in improvement of the high-octane gasoline production. Measured by the power supplied to the propeller by the most modern fuels, the old 100-octane standard has been far exceeded.

Patents for Buna rubber will be transferred permanently from the Standard Oil Company to the United States government, according to an announcement by Ralph W. Gallagher, president. The offer was made by Standard Oil subject to approval of stockholders and was accepted. It involved no payment. The patents involved cover Buna-S, tire rubber that forms the basis of the government's synthetic rubber program. The government agreed to expand its research in the field up to an amount involving not less than $5,000,000.

McBride Refining Company has begun construction of a second still at the La Blanca gas-condensate field east of Edinburg, Texas. The new still will be used exclusively for producing 91-octane aviation gasoline but the present still will continue to produce automobile gasoline. When finished, capacity of the plant will be about 3000 bbl. daily.

Vital materials and new assault weapons have resulted from the huge investment in the petroleum industry's wartime program, according to E. V. Murphree, vice-president of the Standard Oil Development Company, who was the principal speaker at a meeting of the Baton Rouge, Louisiana, section of the American Chemical Society. Stating that approximately one billion dollars had been invested in the development program, Murphree listed the various important weapons that are produced by the industry. Among them was a new incendiary bomb, an improved flame thrower, a smoke generator capable of fogging out whole cities. Production of synthetic toluene from petroleum to make TNT he believes to be the most important step in the war program so far.

Crude Runs to Stills, Production[1] and Stocks[2] of Motor Fuels
Week Ended April 24, 1943
A.P.I. Figures
(Figures in thousands of bbl. 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Production	Total Gas and Fuel Oil Stocks
*Combined: East Coast, Texas Gulf, Louisiana Gulf, North Louisiana-Arkansas, and Inland Texas	88.7	1,667	68.2	10,256	62,046
Appalachian	84.8	159	89.8	799	3,827
Ind., Ill., Ky.	85.0	709	87.4	4,159	25,324
Okla., Kans., Mo.	80.1	350	84.1	2,000	10,055
Rocky Mountain	48.0	99	67.3	616	2,946
California	89.9	753	92.2	3,875	84,513
TOTAL U. S.—B. OF M. BASIS APRIL 24, 1943	86.2	3,737	77.7	22,705	189,711
TOTAL U. S.—B. OF M. BASIS APRIL 17, 1943	86.2	3,672	76.3	22,218	190,054
U. S. B. OF M. BASIS APRIL 25, 1942	.....	3,500	.....	20,678	212,140

(a) Finished 80,918,000 bbl.; Unfinished 10,196,000 bbl.

*At the request of the Petroleum Administration for War.

[1]Production—total of gasoline at refineries including natural and blended; gas oil and distillate fuel, and residual fuel oil.

[2]Stocks—at refineries, bulk terminals, in transit, and pipe lines of finished and unfinished gasoline; gas oil and distillate fuel, and residual fuel oil.

Fluorite, an important mineral used in petroleum refining and in the manufacture of implements of war, has been discovered in large quantities in southeast Hudspeth county, Texas, it was reported by Glen L. Evans of the University of Texas Bureau of Economic Geology.

Midland Coöperative Wholesale of Minneapolis, Minnesota, has purchased the Cushing Refining and Gasoline Company, Cushing, Oklahoma, in a transaction that is said to have involved approximately $1,000,000. The Cushing refinery has a crude oil capacity of 5000 bbl. daily and a cracking plant of 2500 bbl. It will be used to supply motor fuel, kerosine, and distillate fuel for the Midland Coöperative outlets. These outlets comprise some 250 separate coöperative local distribution points in Minnesota and Wisconsin. Storage facilities for 600,000 bbl. of crude oil and products, 110 tank cars, and 100 miles of gathering lines are among other assets of the Cushing plant. Rex. H. Winget, vice-president and general manager of the Cushing plant, remains as manager of the division under the new owners and all members of the staff have been retained.

A plea that the Petroleum Administration for War speed up completion of high-octane gasoline plants at Sinclair and Cheyenne, Wyoming, was made by Senator O'Mahoney, Wyoming, in a letter to Ralph K. Davies, assistant petroleum administrator for war.

The senator pointed out that new oil reserves of 124,000,000 bbl., more than two-thirds of it in Wyoming, have been located in the last six months and he urged immediate expansion of facilities for manufacture of high-octane gasoline.

In addition to the plants at Sinclair and Cheyenne O'Mahoney recommended that immediate consideration be given to construction of a similar plant in the Casper, Wyoming, area. He stated that demand for high-octane gasoline in that vicinity was proved by grounding of army planes at Casper.

The Neches Butane Products Company will produce its first rubber at its Port Neches, Texas, plant in July. By August or September the works is expected to be in full production.

The largest rubber plant in the country is the creation of several companies who pooled their resources to further the war effort and the result drew high praise from William M. Jeffers, rubber director, on a recent inspection tour.

Companies participating in the project are the Gulf Oil Corporation, The Texas Company, Atlantic Refining Company, Pure Oil Company, Magnolia Petroleum Company, and the Lummus Company. The last firm holds the general construction contract. Raw materials from which butadiene is made are a by-product of the five oil concerns' refineries.

A LESSON IN WATER COOLING

LESSON 3 OF A SERIES

AIR MOVEMENT, TOWER PERFORMANCE and PLANT OUTPUT

The maximum production of which a plant is capable requires dependable performance of all equipment at all times. Any weak link, such as an undependable cooling tower that retards the functioning of other equipment, is intolerable today when utmost output of war goods is imperative. Failure of a wind-dependent cooling tower to deliver required water temperatures during periods of low or adverse air movement can partially if not wholly *paralyze* production of high-octane gasoline, synthetic rubber, food, chemicals and machines vital to Victory.

An atmospheric deck type cooling tower that is designed for a higher wind velocity than it will receive *at all times* cannot be considered a dependable auxiliary. This type of tower, if designed on the basis of a given wind velocity, cannot maintain desired cold water temperatures with (a) less wind, (b) during calms or (c) when the wind, regardless of velocity, is blowing lengthwise or obliquely to the tower.

Therefore, since winds are unreliable both as to direction and velocity, atmospheric deck towers must be sized to deliver design performance with *no* wind effect (0 MPH) if they are to maintain uninterrupted efficiency comparable to an induced draft tower. Otherwise, whenever a plant or process depends upon exact and controllable water temperatures, continuous full-capacity operation cannot be assured.

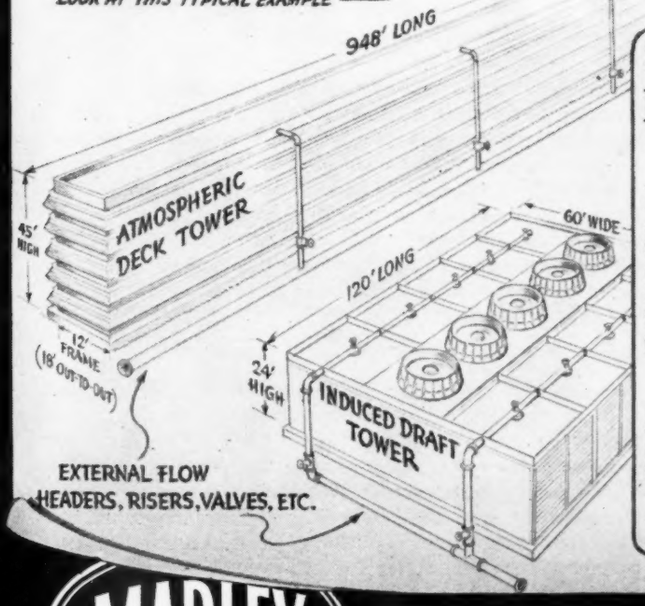
The mechanical induced draft cooling tower creates air movement by means of power-driven fans so that performance and water temperatures are under positive control at all times. Since the cooling medium (air) is furnished in a constant and dependable manner, this type of cooling tower is an always reliable auxiliary.

In addition to its prime advantage of dependability in maintaining full plant production, other factors favoring the induced draft tower include: Less ground space, negligible drift loss, less make-up water, lower pumping head, better appearance, lower first cost, lower operating and maintenance cost, and of especial importance now during wartime, shorter completion time, much smaller use of critical materials, fewer man-hours and less freight.

All these factors together have reduced atmospheric deck towers to a status of virtual obsolescence and practical applications for them are but a small fraction of the total.

WAR PLANTS ARE INSTALLING
20 LARGE-CAPACITY INDUCED DRAFT TOWERS
TO EVERY **1** ATMOSPHERIC DECK TOWER

WHY IS THE RATIO SO DECISIVE?
LOOK AT THIS TYPICAL EXAMPLE —



COMPARING TYPICAL TOWERS FOR IDENTICAL PERFORMANCE

	WIND-DEPENDENT ATMOSPHERIC DECK TOWER	POSITIVE-POWERED INDUCED DRAFT TOWER
CAPACITY - GALLONS PER MINUTE	17,500	17,500
TEMPERATURES - HOT, COLD & WET BULB	100-80-70	100-80-70
PUMPING HEAD - TOWER ONLY	45 FT.	26 FT.
LUMBER - BOARD FEET	385,000	165,000
WEIGHT OF ALL LUMBER AT 3.2 LBS./BD. FT.	1,232,000 LBS.	528,000 LBS.
STRUCTURAL STEEL	—	4,900 LBS.
BOLTS & NAILS - GALVANIZED STEEL	14,100 LBS.	9,300 LBS.
REINFORCING STEEL FOR BASIN	33,200 LBS.	14,300 LBS.
CAST STEEL PARTS	—	3,200 LBS.
CAST IRON - INTERNAL PIPING, PLATES, ETC.	19,000 LBS.	7,100 LBS.
CAST IRON - EXTERNAL HEADERS, RISERS, ETC.	180,000 LBS.	19,600 LBS.
WEIGHT OF ALL STEEL & CAST IRON	246,300 LBS.	58,400 LBS.
ELECTRIC MOTORS - TOTAL WEIGHT	—	4,800 LBS.
MISC. MATERIALS - TOTAL WEIGHT	—	800 LBS.
CONCRETE FOR BASIN - CUBIC YARDS	550	250
WEIGHT OF ALL MATERIALS EXCEPT CONCRETE	1,478,300 LBS.	592,000 LBS.
FREIGHT, ALL MATERIALS EXCEPT CONCRETE	31 CARLOADS	12 CARLOADS

MARLEY COOLING TOWERS

THE MARLEY COMPANY INC.
KANSAS CITY, KANSAS

MAJOR *Pipe Line* ACTIVITIES

WORK has begun on the laying of the southwestern leg of the 20-in. pipe line that will haul petroleum products from Texas to Atlantic Coast refineries, it was announced by Burt E. Hull, general manager of War Emergency Pipelines, Inc., which is constructing both the 24-in. and the 20-in. lines.

Construction crews of the Williams Brothers Corporation were the first to begin laying the pipe. Work of clearing rights-of-way, installing fence gaps, and other preparations are being made by crews of most of the contractors on the line from Baytown, Texas, to Seymour, Indiana. Contracts for this part of the 1476-mi. pipe line are held by:

Williams Brothers Corporation for feeder lines, Houston-Baytown, Texas; 59 mi.

Sharman and Allen for feeder lines, Baytown-Beaumont; 62 mi. Also Port Arthur-Port Neches, Texas; 43½ mi.

N. A. Saigh Company, Beaumont to near Wiergate, Texas; 71 mi.

Winston, Guthrie and Brown, Wiergate to Red River; 71 mi.

Williams Brothers Corporation, Red River to White River, Arkansas; 270 mi.

B. & M. Construction Company, White River to St. Francis, Missouri; 101 mi.

Oil States Construction Company, St. Francis River to Mississippi River; 62 mi.

Swinnerton and Walberg, Mississippi River to Norris City, Illinois; 82 mi.

Midwestern Engineering and Construction Company, Norris City to Patoka River, Illinois; 64 mi.

J. C. Truman Construction Company, Patoka River to Seymour; 78 mi.

The first sections of the line—from Baytown, Texas, to Seymour, Indiana, were approved several weeks ago by Defense Plant Corporation, subsidiary of Reconstruction Finance Corporation, which is financing the line. The new section—from Seymour to the East Coast—was approved in April. Overall cost of the project will be approximately $75,000,000. The facilities will be owned by DPC and will be operated for the account of Defense Supplies Corporation by War Emergency Pipelines, Inc.

The "Little Big Inch" is scheduled to be completed to the Atlantic Coast about December, 1943. It will have a maximum delivery capacity of 235,000 bbl. of petroleum products daily.

◆

Possibility of a third pipe line to carry oil to the East Coast was revealed when orders were given for surveys by the Petroleum Administration for War in Washington. The line was proposed by Vincent Shinkle, consulting petroleum engineer for the Trans-American Pipeline Corporation. He stated that the construction of a 12¾-in. pipe line from the Tinsley oil field in Yazoo County, Mississippi, to Savannah, Georgia, or Charleston, South Carolina, or both, a distance of 600 miles, had been authorized by congress and a $13,000,000 appropriation made to cover the cost of constructing it.

◆

The 14- and 16-in. natural gas transmission line from Refugio to Pierce Junction, Texas, has been sold to the government for $2,625,000 by the Houston Gulf Gas Company, Houston, Texas. The government expects to convert the line into an oil pipe line.

Recommendations for the construction of a pipe line to the Hugoton, Kansas, gas field to aid in fuel distribution were made in Kansas City, Missouri, by western governors and mayors called before the special Senate committee investigating the fuel situation.

◆

Two 8-in. pipe lines have been completed by the government at a cost of nearly $10,000,000. One is across the Isthmus of Florida, 200 miles in length, running from Carrabelle, on the west coast, to Jacksonville. The second line connects at Greensboro, North Carolina, with existing systems extending from Baton Rouge, Louisiana, and the Houston-Beaumont area of Texas. It is pumping 30,000 bbl. of petroleum products per day to its terminal at Richmond, Virginia, 175 miles away.

The Florida pipe line is expected to be in operation within a few days and will carry approximately 16,000 bbl. a day initially. Deliveries will be stepped up to 28,000 or 30,000 bbl. of gasoline by June. This is the first pipe line to have both its supply and distribution depend upon barges, and for this reason more time is needed to build up the flow to capacity. Barges must haul the gasoline from the Texas refining areas to Carrabelle, the supply end of the pipe line. Other barges must be ready at Jacksonville to receive the products at that end of the line.

◆

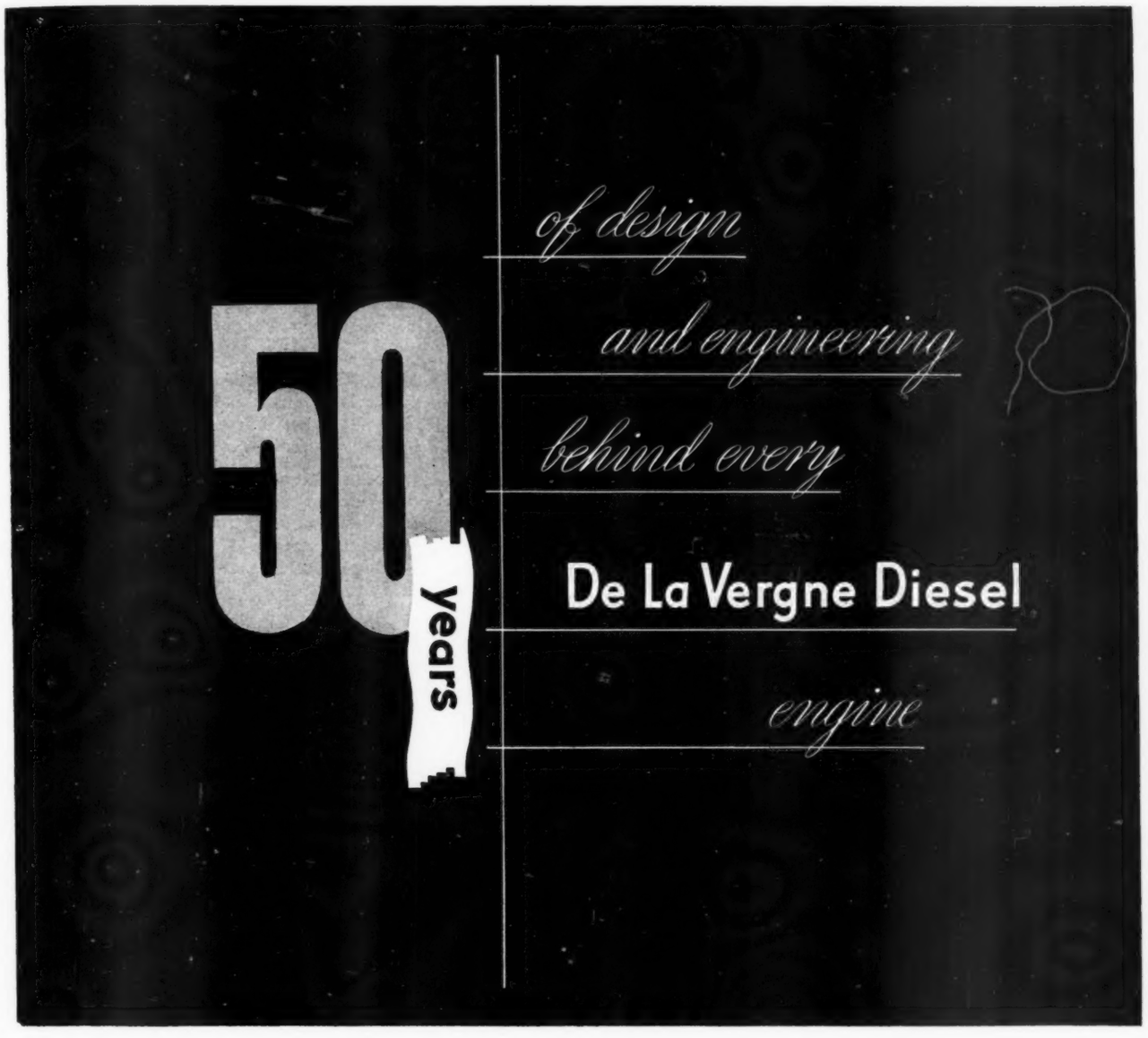
Under consideration by the Petroleum Administration for War is the construction of a large pipe line to provide middlewestern refineries with additional supplies of West Texas crude oil. Middlewestern refineries will ultimately have to be supplied with crude oil from more distant sources, it was stated in a release by Administrator Harold L. Ickes, and the problem may become acute before 1944.

The suggested pipe line would run from a central point in the West Texas area to a point of connection with existing pipe lines that serve the middlewestern refineries. One company has already made a proposal to construct a 10-in. line from near Lubbock, Texas, to the vicinity of Drumright, Oklahoma, to connect with existing pipe lines that feed the middlewestern refining centers.

Studies are being made from the standpoints of petroleum economics, transportation necessities, and engineering. The pipe line proposal already submitted for approval by PAW calls for the private financing of approximately 383 miles of new pipe lines requiring a minimum expenditure of 42,645 tons of steel and approximately $7,000,000. It was pointed out that the "Big Inch" and "Little Big Inch" had first call on the steel and other critical materials available for the expansion of petroleum transportation at this time.

◆

Demands of three American Federation of Labor unions for a closed shop and employment of Missouri men exclusively caused suspension of work for a week on the southeast Missouri section of the government-financed pipe line to the East Coast. Work was resumed May 5 after Governor Forrest C. Donnell had sent the Sixth Missouri Infantry into Scott County to preserve order. Outbreaks of violence between employees of the Oil States Construction Company and the Dunn Trucking and Construction Company, and union members brought arrests for peace disturbance or hospitalization for several of those who participated.



In 1893, De La Vergne built its first oil engine, which today is considered by many to be the forerunner of the modern diesel engine. Starting with the oil engine, every De La Vergne that has followed has been engineered and designed to meet the exacting requirements of the application.

De La Vergne has built diesel engines for practically every type of application. Ranging from 200 bhp to 1,600 bhp, they have provided unfailing low cost power in ice plants, marine and diesel-electric locomotive installations, industrial plants, textile, cotton oil, and flour mills, public buildings, hotels, colleges and others.

The knowledge and experience gained in 50 years of oil engine manufacturing is built into every De La Vergne.

BALDWIN
De La Vergne
SALES CORP.

SUBSIDIARY OF THE BALDWIN LOCOMOTIVE WORKS • PHILADELPHIA

MAJOR *Oil Field* ACTIVITIES

• **Texas.** A new field in the Sugar Valley area of Matagorda County has been opened by the well Fendell B. Peterson, in P. Burnett and A. S. Sojourner survey, abstract 13. The operators, Superior Oil Company, are drilling at approximately 11,000 ft. in an effort to determine what the area contains. Production showed 17 bbl. of distillate and considerable gas in an 8-hr. test.

• **Oklahoma.** A new pool in Hunton lime was opened by the Ace Gutowsky and D. D. Bourland Wagner No. 1, NWC SW 32-14-4w, west of Edmond in Oklahoma County. Production is holding above 520 bbl. a day from 6877 to 6892 ft.

• **Kansas.** Completion of the J. A. Aylward and C. H. Westfall wildcat in Rice County adds a new pool to central Kansas. The Plogg No. 1, NWC SW 5-18-9w, was brought in for 78 bbl. daily from the Arbuckle lime at 3244 ft.

• **Louisiana.** Hunt Oil Company has opened the large Pine Prairie field in Evangeline Parish to Wilcox production with a completion test on Crowell-Spencer Lumber No. 1 on the west flank of the dome, 35-3s-1w. This gives the field a fourth production horizon. The Wilcox was topped at 10,063 ft. and the well was still in the sand when drilling was discontinued at 10,605 ft. The well flowed 110 bbl. of 38-gravity oil.

• **Illinois.** H. Gussman, E. Phillips and associates opened a new pool for the area northeast of Hoodville, in Hamilton County, Southern Illinois, with Meade No. 1, SEC NW 23-5s-6e. It flowed 158 bbl. in 19 hours from the O'Hara sand at 3210-22 ft.

• **Oklahoma.** County-Line is the name of a pool opened in Pottawatomie County when F. C. Hall, Powell Briscoe and Margay Oil Corporation Dierker No. 1, CSW SW 19-9-2e, began flowing at the rate of 25 bbl. an hour. The Hunton lime formation had been acidized at three points around 5500 ft.

• **Texas.** Coming in at a depth of 9494 to 9541 ft., the Amon G. Carter Walter-Pure No. 2-C, 1-BB-3-PSL, opened up the first Ellenburger lower Ordovician oil production for Winkler County. It flowed 33 bbl. of oil in 30 min. on drill-stem test and gas production was estimated at 10,000,000 cu. ft.

• **Kansas.** Dickinson County has a new oil pool, the Lost Springs Northwest, at Hutchinson and others' Martin No. 1 "B," CW½ SE SW 34-16-4e. It has a state rating of 126 bbl. of oil daily from the Mississippi chat.

• **Louisiana.** A successful test at Humble Oil and Refining Company St. James wildcat, Panno and Bossetto No. 1, opened a new pool on the west side of the Mississippi River about 50 mi. from New Orleans in section 8-12s-16e. The estimated production is 2,250,000 cu. ft. of gas and 90 bbl. of distillate daily from 10,780-86 ft.

• **Texas.** The fourth oil field in Wood County was opened by Bobby Manziel's W. F. Bailey No. 1, Burch survey, 5.5 mi. SE of the Coke field. It flows 248 bbl. a day from Paluxy sand at 6245-6360 ft.

• **Kansas.** The Gustason Northwest is a new pool in Russell County opened by Harry Gore's Kastrup No. 1, NEC 15-15-12w, more than a mile from production. The well has produced a potential of more than 200 bbl. daily from the Lansing-Kansas City lime at 3027 ft.

AVERAGE CRUDE OIL PRICES

California		**Louisiana**	
Kettleman Hills	$1.23-1.29	Rodessa	$ .88-1.20
Playa Del Rey	.80- .87	Gulf Coast	.93-1.36
Coalinga	.73-1.13	North Louisiana	.98-1.30
Wilmington	.68-1.24		
Montana	1.00-1.15	**Illinois**	1.22-1.37
Wyoming	.45-1.15	**Kentucky**	1.32-1.43
Colorado	1.05-1.07		
New Mexico	.70-1.15	**Indiana**	.85-1.25
Texas		**Ohio**	
North Central	.97-1.21		
Panhandle	.70-1.12	Lima	1.50-1.60
West Texas	.80-1.27	**Michigan**	1.24-1.44
Gulf Coast	.93-1.48		
Darst Creek	1.14	**Pennsylvania**	
East Texas	.80-1.27	Bradford	3.00
Talco	.79	Southwest	2.65
Kansas	.93-1.25	Eureka	2.59
Oklahoma	.75-1.25	Buckeye	2.30
Arkansas	.94-1.36	Corning	1.31

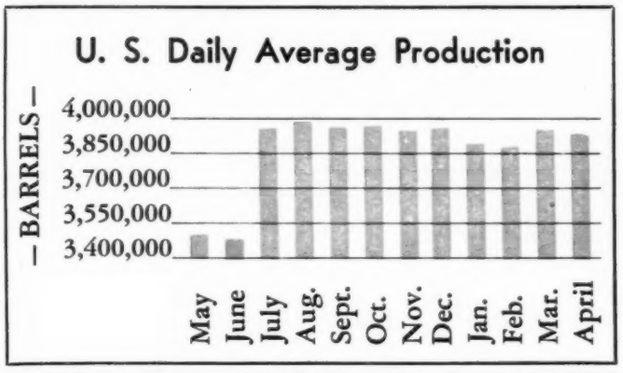
DAILY AVERAGE CRUDE OIL PRODUCTION
Data Supplied by A.P.I.
(Figures in bbl. of 42 gal. each)

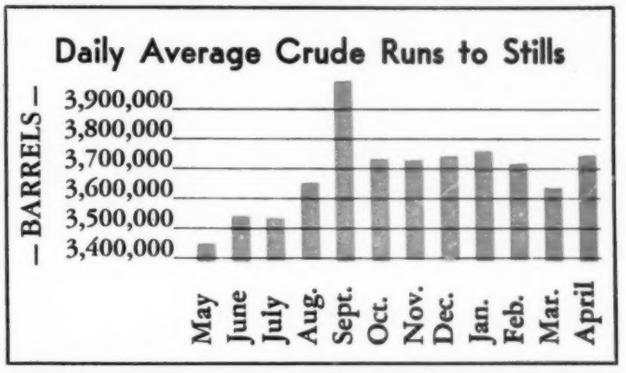
	[1]P.A.W. Recommendations April	Week Ended April 24, 1943	Week Ended Feb. 27, 1943	Week Ended April 25, 1942
Oklahoma	379,300	[2]341,450	390,700	400,750
Kansas	309,900	[2]318,800	309,900	253,200
Nebraska	2,600	[2] 2,200		3,900
Panhandle Texas		91,000		90,050
North Texas		134,950		147,550
West Texas		214,450		190,200
East Central Texas		99,700		79,450
East Texas		319,800		225,850
Southwest Texas		188,500		156,900
Coastal Texas		340,750		228,550
TOTAL TEXAS	1,502,090	1,389,150	1,501,801	1,118,550
North Louisiana		88,400		77,700
Coastal Louisiana		257,900		239,850
TOTAL LA.	359,300	346,300	370,300	317,550
Arkansas	78,600	72,200	74,826	73,500
Mississippi	50,000	53,650		94,700
Illinois	251,900	225,250		298,800
Indiana	16,000	12,300		18,600
Eastern (Not incl. Ill., Ind., Ky.)	94,300	75,700		87,500
Kentucky	20,000	21,150		11,200
Michigan	63,700	57,100		60,800
Wyoming	97,100	92,300		93,600
Montana	24,600	20,250		21,600
Colorado	7,400	6,850		5,300
New Mexico	105,700	97,250	105,800	79,400
TOTAL EAST OF CALIF.	3,362,400	3,131,900		2,938,950
California	823,700	780,700	823,700	642,400
TOTAL U. S.	4,186,100	3,912,600		3,581,350

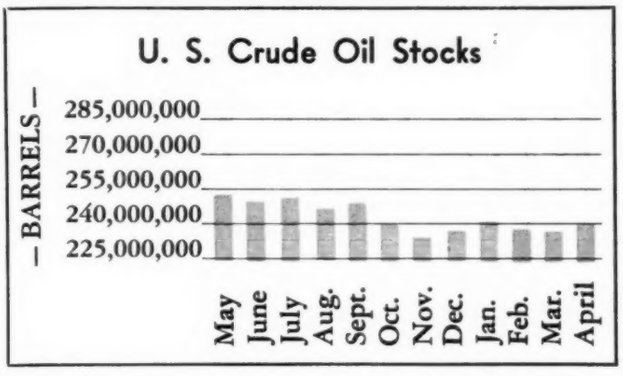
[1]P.A.W. recommendations and state allowables represent the production of all petroleum liquids, including crude oil, condensate and natural gas derivatives recovered from oil, condensate and gas fields. Past records of production indicate, however, that certain wells may be incapable of producing the allowables granted, or may be limited by pipe line proration. Actual state production would, under such conditions, prove to be less than the allowables. The Bureau of Mines reported the daily average production of natural gasoline and allied products in January, 1943, as follows: Oklahoma, 27,900; Kansas, 5,800; Texas, 101,100; Louisiana, 19,800; Arkansas, 2,500; Illinois, 10,300; Eastern (not including Illinois, Indiana or Kentucky), 9,500; Kentucky, 3,100; Michigan, 100; Wyoming, 2,300; Montana, 400; New Mexico, 5,700; California, 42,500.

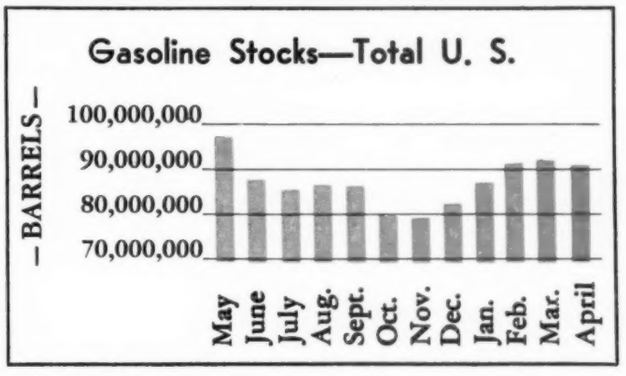
[2]Oklahoma, Kansas, Nebraska figures are for week ended 7 a. m., April 21.

PETROLEUM *Statistics* AND FIELD *Operations*









Above statistics by American Petroleum Institute.

Summarized Operations in Active Fields for April, 1943

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
Eastern Texas	30	14	6	....	3500-3700	2	40	Rotary
Gaines County	2	1	5	....	4400-5584	2	22-35	Rotary
Hockley County	4	2	3	....	4800-6850	2	20-30	Rotary
Ector County	4	3	5	....	3675-4377	2 or 3	32-36	Rotary
Panhandle	23	12	4	....	1700-3900	2	40	Rot.-Cab.
Nueces County	6	5	6	....	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	3	2	4	....	3730-2935	2	42-43	Rot.-Cab.
Hawkins Field	5	3	4	....	4495-4912	2	19-29	Rotary
OKLAHOMA								
Okfuskee County	3	1	6	3	2150-4125	2 or 3	38	Rotary
KANSAS								
Russell County	8	6	5	....	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	5	3	5	....	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	3	2	3	....	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	147	104	60	126	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	13	9	6	3	3150-4030	2	30-34	Rot.-Cab.
CALIFORNIA								
Kern County	2	1	5	2	1840-11,450	3 or 4	14-30	Rotary
Wilmington County	4	2	4	2	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for April, 1943

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1942 (In Barrels)
	April	March	April	March	April	March	April	March	April	March	
Arkansas	20	21	6	11	6	20	3	8	4	17	26,560,000
California	56	86	44	69	12	15	21	28	15	35	248,250,000
Illinois	147	153	104	112	36	44	60	66	126	138	105,768,000
Indiana	25	25	18	11	18	10	4	4	3	6	6,680,000
Kansas	141	101	97	62	41	50	15	12	12	16	96,920,000
Kentucky	6	30	4	19	1	12	....	....	....	....	4,503,000
Louisiana	153	45	102	30	51	25	18	10	9	14	125,450,000
Michigan	20	31	16	13	6	7	11	9	4	3	21,568,000
Mississippi	6	2	3	1	....	....	....	....	....	....	27,605,000
Montana	10	5	4	5	....	....	....	....	....	....	8,998,000
Nebraska	1	....	1	....	2	2	....	....	....	....	1,367,000
New Mexico	33	20	25	13	23	16	....	....	....	....	31,875,000
New York	74*	78*	61*	77*	50	46	....	....	....	....	5,132,000
Ohio	54	59	43	42	32	40	....	....	....	....	3,480,000
Oklahoma	127	102	116	70	24	13	1	9	41	69	138,750,000
Pennsylvania	111*	166*	94*	160*	110	110	....	....	....	....	17,256,000
Texas	296	302	171	152	290	288	301	279	180	300	476,560,000
West Virginia	26	28	19	26	3	18	6	8	3	7	3,780,000
Wyoming	2	4	1	4	1	4	1	1	....	2	32,778,000
Total	1308	1058	929	867	706	720	441	434	397	607	1,383,280,000

*Includes water-intake and pressure wells.

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P 420.112.

THE Petroleum Engineer

MAY, 1943

Locating Cased-Off Production By Radioactivity Logging

PETROLEUM ENGINEER Exclusive Feature

☆ Neutron curve supplements well data obtained by use of gamma-ray

by Wallace A. Sawdon

Pacific Coast and Foreign Editor

THE success achieved by use of radioactivity logging to locate oil production behind casing has recently been augmented by the use of a second curve. This is the neutron curve, which will frequently aid in determining the character of the formation behind the pipe and which is generally employed as a companion curve to the gamma-ray curve that originally was used alone in radioactivity logging. In addition to providing additional information such as locating the porous strata in limestone in the Gulf Coast and Mid-Continent areas, the neutron curve will sometimes disclose zones where irregularities of radioactivity intensity make the gamma-ray curve inadequate when used alone. For example, the extremely high radioactivity of the sands in certain areas of California, particularly in some fields in the San Joaquin Valley, require the use of the neutron curve to provide reliably interpretative data on the formations being logged. Both the gamma-ray and neutron curves are therefore being taken when radioactivity logs are run in a new area although either of the curves may sometimes be omitted in later surveys when correlations indicate that one—and which one—will supply the necessary data.

Gamma-ray and Neutron Curves

The gamma-ray curve is a measure of the natural gamma-ray intensity of the formations. The gamma-rays originate in the formation and pass through the casing and cement or other material in the hole and thus identify by means

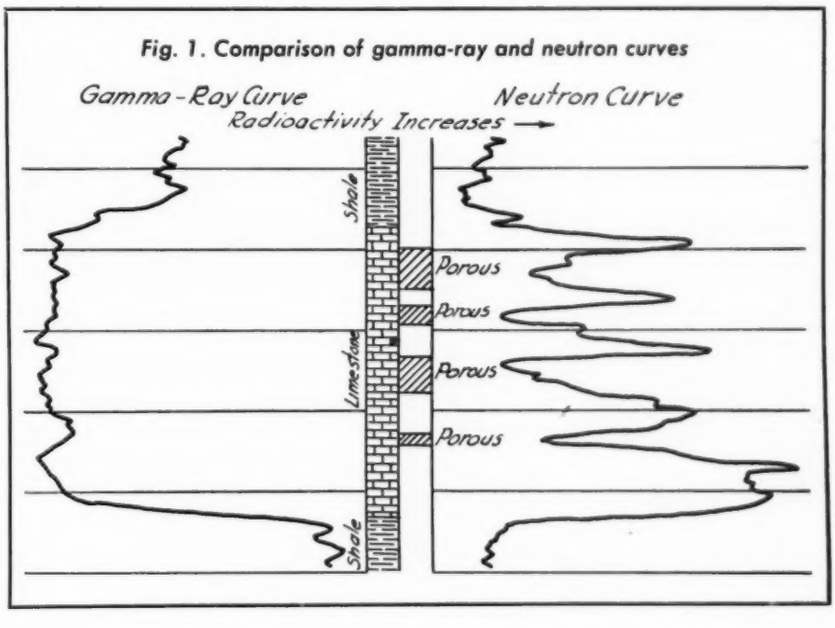


Fig. 1. Comparison of gamma-ray and neutron curves

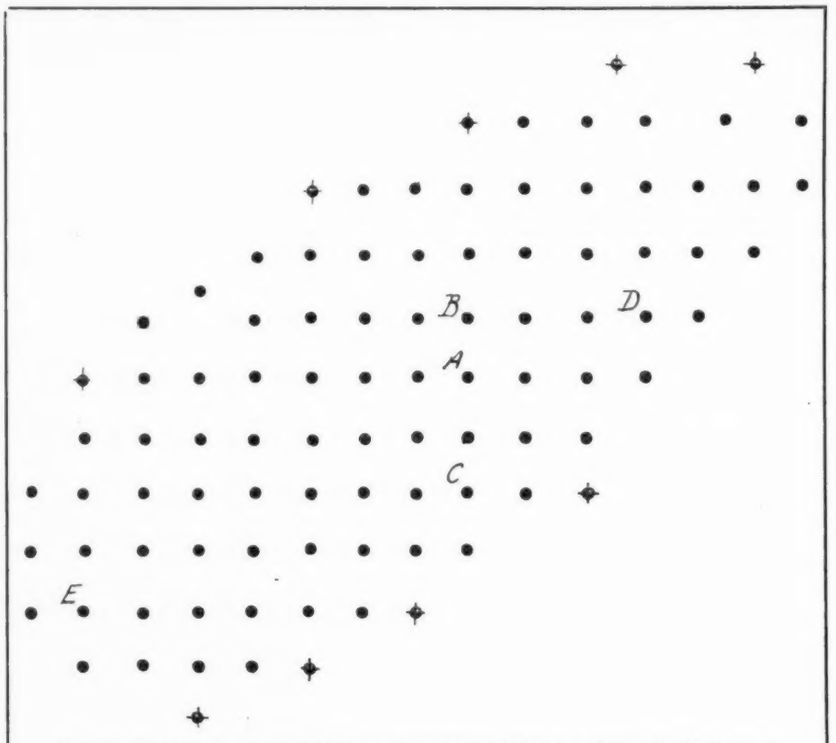


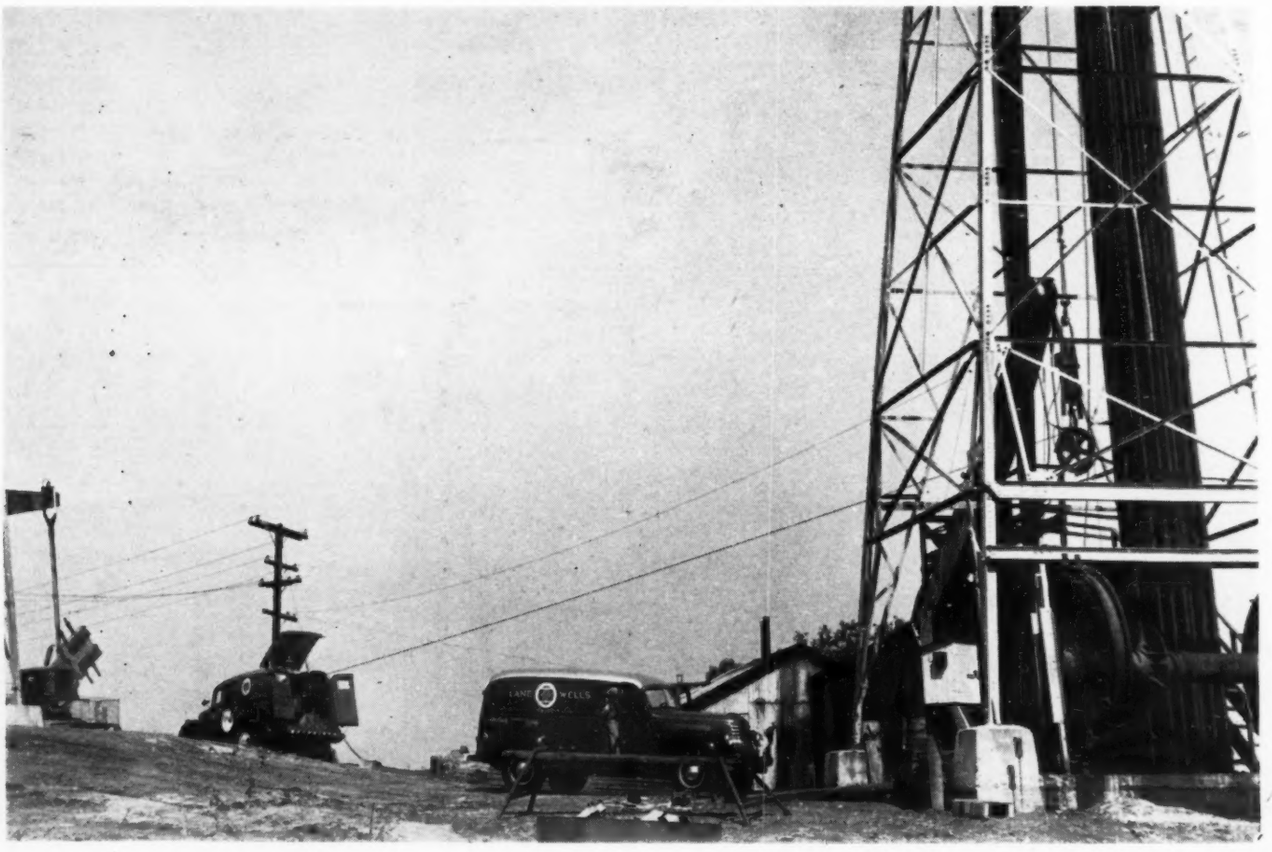
Fig. 2. Pattern for recompletion operations. This is a hypothetical pool

of their relative measurements the character of the formations. The neutron curve, on the other hand, measures the effect of the bombardment on the formations by a strong source of neutrons. This source is within the instrument; and variations in the radiation returning from the formations to an ionization chamber are measured to make the neutron curve.

The radioactivity logging equipment used for making a gamma-ray curve has been described in a previous article.[1] The surface equipment, including the device for recording the curve, is the same for the neutron curve as that used for the gamma-ray curve. The subsurface instrument, however, consists of a neutron source in the lower section of the instrument, a suitable shield above this source, an ionization chamber, and a subsurface amplifier. The instrument is 4⅝-in. OD or 3⅝-in. OD (either size being available) and is 10 ft. in length. It is run into the well on an electric cable in the same manner as the gamma-ray instrument.

[1]"Locating Cased-Off Productive Zones," by Wallace A. Sawdon, *The Petroleum Engineer*, May, 1942.

The recording device and other surface instruments are housed in a truck. As can be seen, the sheave is suspended in the derrick



Comparison of Curves

A comparison of the gamma-ray and neutron curves can be made from the log given in Fig. 1. In general, shales show the highest gamma radiation; sands and shales show less gamma radiation. Radioactivity increases toward the right on the charts, the gamma-ray curve indicates shales to the right with sands and limestone to the left.

The hydrogen present in the formation is the chief cause of variation in the intensity of the neutron curve so the water content in a formation greatly absorbs the neutron radiation. As the hydrogen content of shale, due to connate fluid and the chemically combined water in the shale, is generally higher than that of sand or limestone, shales show the lowest intensity on the neutron curve and are to the left whereas sands and limestone are to the right. An increase in porosity is indicated by a decrease to the left on the neutron curve and a very porous formation containing fluid will appear as a low intensity value with slightly greater magnitude than shale. Both oil and water contain hydrogen so the curve does not distinguish between these two fluids; correlation from one well to another determines different horizons.

Neutron logs may be taken with or without fluid in the hole but because the instrument is extremely sensitive to fluid it is necessary to have the fluid level below or above the formations being logged. The curve shifts suddenly when the instrument reaches the top of the fluid and this indicates the fluid level accurately.

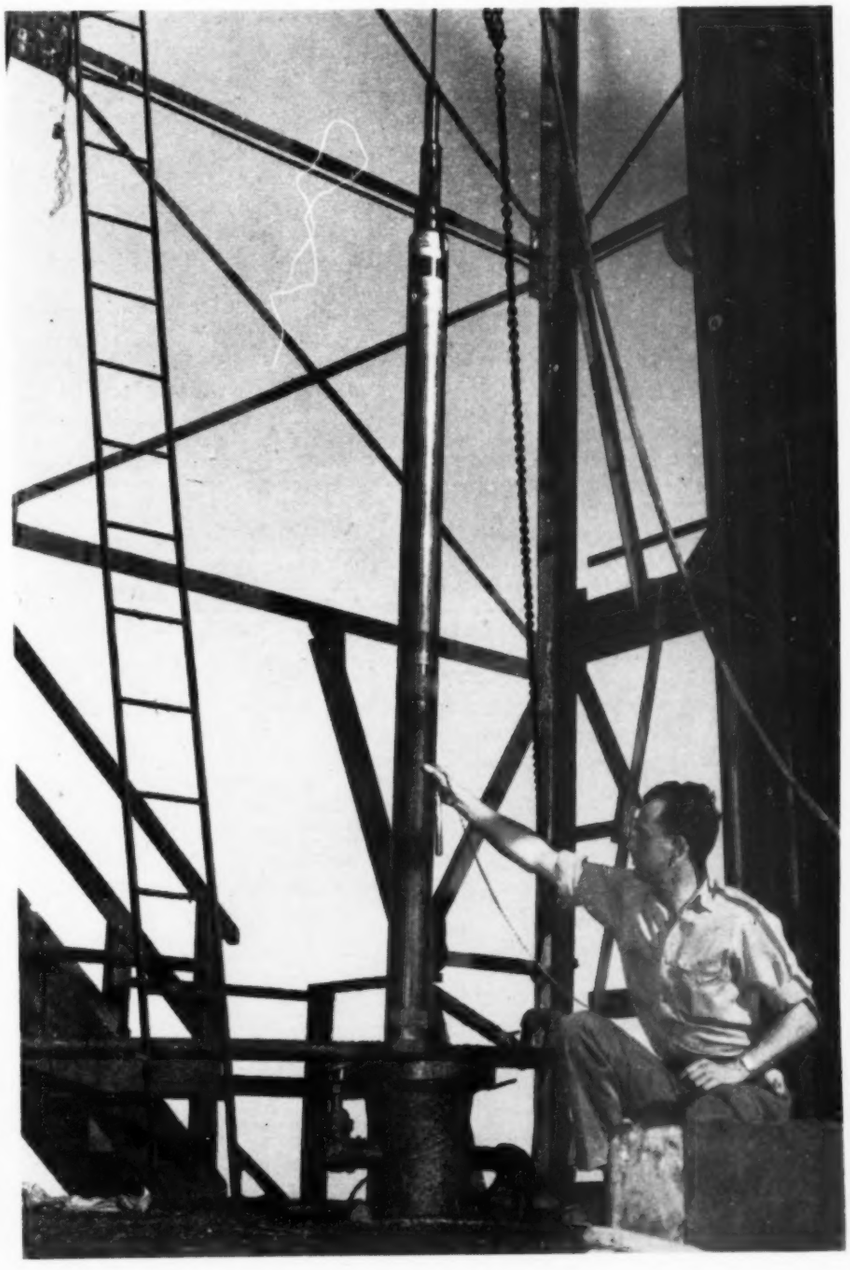
Advantages of Curves

The value of the two curves as complements is evident and the use of both is usually required to determine the porous zones. In the case of the limestone horizon shown in Fig. 1, the gamma-ray curve clearly indicates the limestone between the upper and lower bodies of shale but the neutron curve shows the porous formations within the limestone body. The appearance of the neutron curve is somewhat similar to that of a shallow resistivity curve of an electrical log, although the neutron log is an entirely different type of measurement.

Although a great amount of extra production has been obtained by opening up cased-off production in California during the last year there now appears to be a trend toward a more systematic program of locating the cased-off zones in a number of the older fields. As radioactivity logging has proved its adaptability to accurate location of the productive limits of sands behind the casing, this means of determining the place at which to gun-perforate the string or strings of pipe will be utilized in the operations. By using the radioactivity log the zones to be perforated are limited and savings thus made in gun-perforating. Reliance until recently had to be placed on the gamma-ray curve alone but with the introduction of the neutron curve the irregularities in radioactivity intensity in certain areas in the state can now be overcome.

When going into a new area of California with radioactivity logging, both the gamma-ray and neutron curves are now generally taken. If, after correlation, it is found that one of the curves gives all the data necessary, that curve can be used alone for wells logged subsequently in that field. In some areas the use of both curves may be necessary in only one well; in others, both curves may have to be taken in several wells; and in still other areas both curves may be necessary in all the wells logged.

Several of the major companies with large acreage in a single field are planning recompletion operations by establishing a pattern. As an example, a hypothetical pool is shown in Fig. 2. Some of the wells will have been drilled recently enough to supply electrical logs and these logs can be used for correlating with the radioactivity logs



The radioactivity logging instrument is run into the well on conductor cable

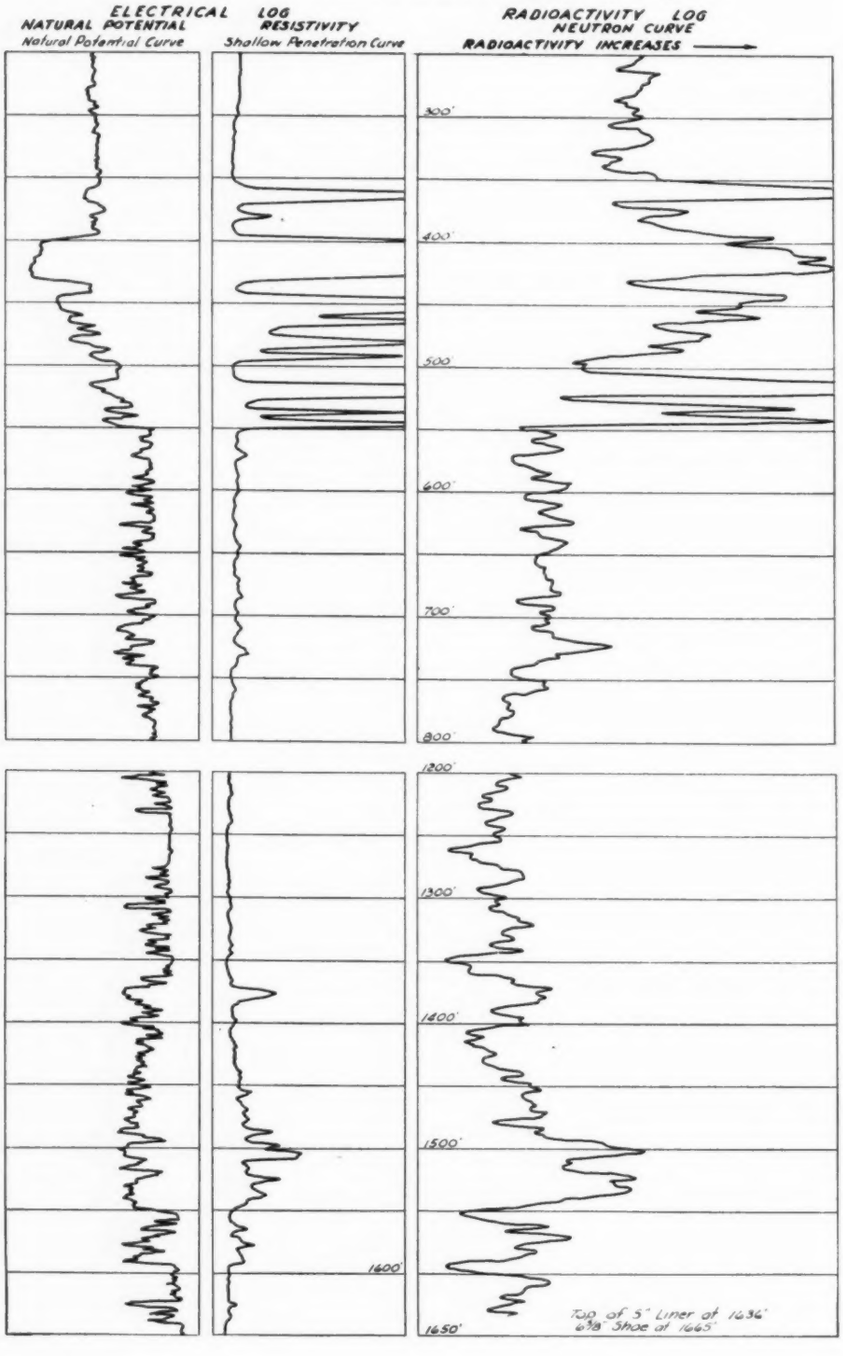
—(Photo courtesy Lane-Wells Company)

to be taken in other wells where recompletion by gun-perforating of cased-off production is to be done. (See Fig. 3.) If no electrical logs are available the radioactivity logs will supply all data for correlation and, as both the gamma-ray and neutron curves can be used, the lack of electrical logs is not so important.

Method of Use

One well, such as that indicated by "A," is selected for the first gamma-ray and neutron logs. In well "A" a potential productive zone is known to exist and from the data provided the same zone in other wells can be located. Then wells "B" and "C" are logged, these wells being offsets or at least near the first well and generally on a line with it. A fourth log is taken in a well, such as "D," that is located on a line at right angles to the line of the other wells previously logged but usually several locations distant. The logs of one or two wells down structure, as at "E," may be taken to procure data on the flanks.

Fig. 3. The neutron curve of a radioactivity log can here be compared with an electrolog taken in the same well in a San Joaquin Valley field



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With these logs, using both curves, a pattern of the field can be made and definite markers established that will reduce the radioactivity operations in subsequent wells. From the curves obtained it may be possible that only one curve will be necessary for logging the remaining wells in the field or on the lease that is assumed to cover a substantial acreage with a considerable number of wells. In many fields the well spacing may not be as regular as that shown in Fig. 2 but the selection of wells from which to make a pattern can easily be made to meet the conditions.

The use of radioactivity logging has increased the production in California substantially and continued use is considered a step toward greater increase of the much-needed production demanded by the war effort in the state.

The discovery well of one of the old larger California fields stopped producing, but had not been abandoned. A radioactivity log was recently run to locate potential production that had been cased-off. The well was then recompleted according to the data obtained with the result that substantial production was obtained.

☆ ☆ ☆

P 509.12
P 952.1

Calculating Production Decline Curves for Natural Gas Wells

PETROLEUM ENGINEER Exclusive Feature

☆ A proposed method for application of back-pressure data to analysis of future availability of gas reserves

PART I

by Albert R. Greer

APPLICATION of back-pressure data to the analysis of the future availability of gas reserves has been shown to be a substantial aid under certain conditions. If the gas reservoir retains its original size, or if conditions of flow from the reservoir are such that the drop in formation pressure is directly related to the volume of gas produced, and production is controlled at a constant rate for set intervals of time, the decline curve is readily calculated.

For these conditions a curve may be predicted, calculations based on the following general principles:

1. The wells will be assigned production rates depending on their open flow capacities when tested at regular intervals; such as 25 percent of the open flow.
2. The wells will be produced at this rate for a definite length of time.
3. From the amount of gas that will be produced in this interval the pressure drop and formation pressure can be calculated.
4. From the formation pressure the open flow (using the "back-pressure curve"*) can be predicted and the resulting rate of production determined—and so on for the estimated life of the well.

It is probable that most gas wells will be produced in the manner shown above. There may be times, however, when wells are produced against a rather constant back-pressure for long intervals of time, and the production of each well is not regulated to a definite rate, but is dependent only on the capacity of the well to produce under the given conditions. This type of production may be used when line pressures are kept high to avoid compressing, and the formation pressure is, or has dropped to, within 200 or 300 lb. of the line pressure. It is especially adaptable to wells with large reserves and sand that exhibits a low permeability.

*"Back-pressure curve" as used in this article refers to a plot of the equation,

$$Q = (C)\ (P_f^2 - P_s^2)^n,$$

as give in Monograph 7, U. S. Bureau of Mines.

ALBERT R. GREER

received a B.S. degree in petroleum engineering April 30, 1943, from the New Mexico School of Mines—In successive years at school worked as student instructor in the chemistry, physics, and petroleum engineering departments—Employed two summers as a surveyor for the Department of the Interior and one summer as clerk for Anderson-Prichard Oil Corporation—Is a member of the Naval Reserve and will leave for active duty this summer.

At times it may be more feasible to allow the wells to produce for several years against this constant back-pressure, supplying more gas to meet current demand by drilling more wells or obtaining it from some other source rather than lower the line pressure and increase compressing costs.

It is with this manner of production that this article is concerned. A proposed method of calculating production decline curves for wells operated in this manner is given herewith.

The conditions necessary and on which the method is based are as follows:

1. The wells are produced against a constant back-pressure for the length of time with which the curve is concerned.
2. The drop in formation pressure is directly related to the amount of gas produced.
3. The relation of formation pressure, back-pressure, and rate of flow as determined by back-pressure tests[3] holds true, or nearly so, throughout the time of production covered by the curve.
4. The total reserves underlying each well must be known.
5. The method holds for one well, or may be used for a group of wells if a true straight line† composite curve[1,2] showing back-pressure results is determined.

The principle underlying the method is that as gas is produced the rate of production declines, and is at any one time dependent on the formation pressure (and the constant back-pressure) for its value. The formation pressure, in turn, is dependent on the rate of production in that it determines the amount of gas withdrawn over a given time interval, which is the cause of the drop in formation pressure. The establishment of the relation between the time of production and the amount produced will give a means whereby an accumulated production curve can be plotted. As the formation pressure at any time is dependent on the accumulated production, the formation pressure can be determined indirectly from the curve at any time and the rate of production at that time determined from the "back-pressure curve." A plot of several of these points will give the rate-of-production decline curve.

PART 1
Calculating Production Curves

If the gas does not deviate from the perfect gas laws and the conditions outlined above are fulfilled, the relation of the volume of gas produced to the time

[2]"Back-Pressure Data on Natural-Gas Wells and Their Application to Production Practices," *Monograph 7, U. S. Bureau of Mines.*

[3]"Estimating availability of Natural Gas Reserves," by Paul C. White, *The Petroleum Engineer*, December, 1940.

[2]"A Critical Analysis of the Application of the Back-Pressure Method in Studies of Gas Reserves," by J. William Ferguson, *The Petroleum Engineer*, September and November, 1941.

†Straight line when plotted on log-log paper, as with the other "back-pressure curves."

required can be expressed:

$$\frac{R}{P_r C}\left(\frac{1}{(2n-1)\left(P_r-\frac{P_r V}{R}\right)^{2n-1}}+\frac{nP_s^2}{(2n+1)\left(P_r-\frac{P_r V}{R}\right)^{2n+1}}+\frac{(n^2+n)(P_s^4)}{(4n+6)\left(P_r-\frac{P_r V}{R}\right)^{2n+3}}\right)$$

$= t + \text{constant}$ . . . . . equation (1) (approx.) [derivation given in appendix]

accuracy.‡ This, however, may require six or seven terms.

Use of equation (1) to determine the accumulated production curve is often quite tedious if several terms must be used, as 8 or 10 points are necessary in order to define the curve. Because of this, the following approximate method was developed and is proposed for obtaining these curves.

Several curves with values of n varying from ½ to 1½ have been plotted and found to have a definite relation in spacing. An example is shown in Fig. 1. The perpendicular distance between the curves for most of their lengths is nearly directly proportional to the difference in value of n. This is not strictly true, but holds within a few percent. As simple, exact relations between V and t can be determined for values of n equals ½, 1, and 1½, these curves can be easily and accurately plotted. The curve corresponding to an intermediate value of n§ can be determined by plotting two curves (n equals ½ and 1, or n equals 1 and 1½) and interpolating between for the desired curve.

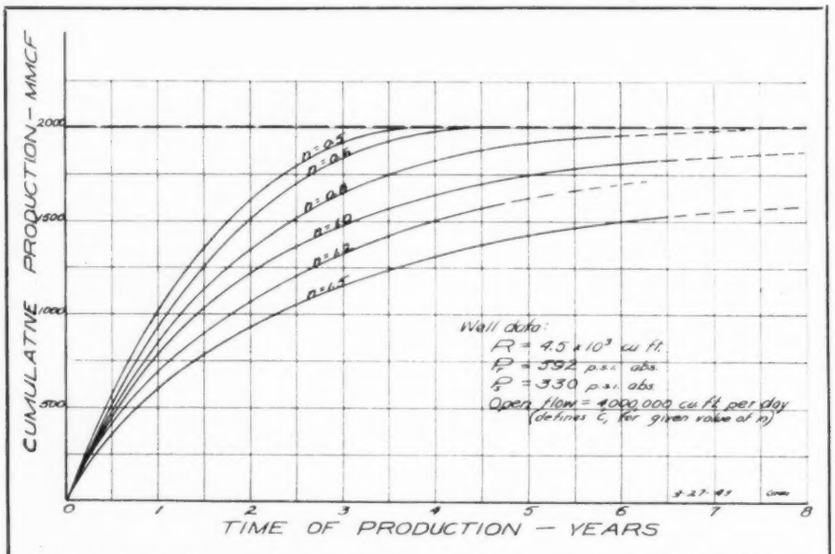

CUMULATIVE PRODUCTION – MMCF
TIME OF PRODUCTION – YEARS
Well data:
R = 4.5 x 10⁹ cu ft
Pr = 592 p.s.i. abs.
Ps = 330 p.s.i. abs.
Open flow = 1,000,000 cu ft per day
(defines C, for given value of n)

Fig. 1. Cumulative production curves. Effect on curve with variation of "n"

Where:

P_r = formation pressure at the time when t is 0, lb. per sq. in. abs.,

R = total reserves underlying the well at the formation pressure, P_r, cu. ft.,

V = volume of gas produced in the time t, cu. ft.,

t = time of production, beginning when the formation pressure is P_r, days,

C, n = experimental constants in the flow equation, $Q=C(P_f^2-P_s^2)^n$, when Q is in cu. ft. per day, and $Q=C(P_f^2-P_s^2)$ fi4fvnt(i

P_s = pressure at sand face (this is the "back-pressure" as referred to in this article), lb. per sq. in. abs.

The constant of integration may be determined by substituting the values of P_r, P_s, R, C, and n when t (and V) are zero. The points for the curve are more readily obtained by substituting values of V and solving for t. Equation (1) is the result of an expansion and integration. If this expansion is carried to enough terms a curve for any value of n can be obtained correct to any desired

The equations giving the relations between V and t for values of n equals ½, 1, and 1½ are shown below. All derivations are given in the appendix. For simplification, the equations are expressed in terms of P_f, rather than in terms of V. Substitution of

$$P_f = P_r\left(1-\frac{V}{R}\right) \quad \text{. . . equation (2)}$$

for P_f, in each of the equations will give the desired relation.

When n = ½:

$$\frac{R}{P_r C}\left[\log_e\left(P_r+\sqrt{P_r^2-P_s^2}\right)-\log_e\left(P_f+\sqrt{P_f^2-P_s^2}\right)\right]=t \quad \text{. . . . . equation (3)}$$

When n = 1:

$$\frac{R}{P_s P_r C}\left[\tanh^{-1}\frac{P_s}{P_f}-\tanh^{-1}\frac{P_s}{P_r}\right]=t \quad \text{. . . . . equation (4)}$$

When n = 1½:

$$\frac{R}{P_s^2 P_r C}\left(\frac{P_f}{\sqrt{P_f^2-P_s^2}}-\frac{P_r}{\sqrt{P_r^2-P_s^2}}\right)=t \quad \text{. . . equation (5)}$$

Each of the above equations expresses an exact function and is readily solved for t by substituting values of V.

Example No. 1

Consider a well with large reserves producing from a sand of low permeability. The well is to be produced against a back-pressure of 330 lb. per sq. in. abs. at the sand face. It is desired to determine the accumulated production curve and the rate of production decline curve.

The well data given:

$R = 4.5 \times 10^9$ cu. ft.

P_r = 592 lb. per sq. in. abs.

P_s = 330 lb. per sq. in. abs.

n = 1.15

C = 1.262 (cu. ft. per day)

The open flow of this well from the above information would be 3,000,000 cu. ft. per day.

The maximum volume of gas possible to produce against the 330 lb. back-pressure is $\frac{592-330}{592}\times 4.5\times 10^9$, which is 2.0×10^9 cu. ft. Equations (4) and (5) are solved for several values of V between 0 and 2.0×10^9 (see Table 1). The constant, C, must be given a different value for each value of n. It is determined by solving for C under open flow conditions. When n = 1,

$$C = \frac{Q}{P_f^2-P_s^2} = \frac{3{,}000{,}000}{(592)^2} = 8.52 \text{ (cu. ft. per day)}$$

and similarly, when n is 1.5, C = 0.01452.

The two curves are plotted (Fig. 2) from the calculated points and the location of the curve for n = 1.15 is determined by direct interpolation. From the new curve, accumulated production and formation pressure at any time can be found. From the formation pressure the rate of flow for that time can be determined from the equation $Q = 1.262(P_f^2-330^2)^{1.15}$, or from a plot

‡"Accuracy" here refers to the exact solution of the differential equation given in the appendix. The closeness with which the predicted curve will fit the actual one is dependent on several other factors, some of which are discussed later.

§Values of n normally found in the field will lie between n equals ½ and n equals 1½ (Monograph 7).

of this curve. Several of these points plotted give the rate of production decline curve.

Suppose the well in Example No. 1 were to be produced against the 330 lb. per sq. in. back-pressure until the production rate dropped to 500 M. cu. ft. per day, at which time it is to be produced into a low-pressure gathering line. From the curves in Fig. 2, it can be seen that this point will be reached in approximately 4 years, and the well will have produced nearly 1.35 billion cu. ft. These facts might be of importance to the operator if the gas has a higher value at the greater pressure. It is true that the volume of gas that can be produced by the time the production rate drops to 500 M. cu. ft. per day can be determined* without the use of the curves, but the length of time required for the production could not be ascertained. The importance of this time rate may be seen from the fact that a well with an open flow of 3,000,000 cu. ft. per day and other conditions the same as the well given above, but with an n of 0.5, would have produced about 1.9×10^9 cu. ft. in the same length of time (4 years). This is a difference of about 40 percent of the first well's cumulative production.

If the value of the gas at the larger pressure is substantially higher than at the lower pressure, the curve would be of assistance in predicting the manner of production for the most profitable returns. That is, at what future date, or rate of production, would it be advisable to produce more gas at lower pressure for less value per M. cu. ft. than to continue producing less gas at the higher pressure with higher value per M. cu. ft. and greater ultimate income (which is offset by discounting, or interest depreciation, due to delayed production).

Accuracy of the Method

The degree of conformity between the predicted curves and the actual ones will depend on the factors that were previously described as being the conditions on which the method was based. In more detail, they are:

1. Continued production at constant back-pressure at the sand face. If the line pressure is constant throughout, the back-pressure at the sand face will also be very nearly constant, as the only other possible variables to be considered are the weight of the column of gas (which will be practically the same if the line pressure is constant) and the difference in pressure due to friction as the gas moves upward from the producing zone. The amount of friction is dependent on the rate of flow of gas through the casing. As the rate of flow changes with time, the friction drop and, consequently, the pressure at the sand face have changing values. Under the ordinary conditions of production (in regard to rate of flow and diameter of producing string) this difference in friction drop for different rates of flow can be considered negligible. Hence, a constant line pressure can be considered as indicative of a constant back-pressure at the sand face.

2. The drop in formation pressure is directly related to the amount of gas produced. This is dependent on reservoir conditions, but if the volume-per-pound method of calculating reserves can be applied to the reservoir, it will apply in the method described and comparable degrees of accuracy can be expected.

3. The relation of formation pressure, back-pressure, and rate of flow as determined by back-pressure tests holds true, or nearly so, throughout the time of production covered by the curve. This relation may change with time,[1,3] but in general it remains constant throughout the life of the well; at least constant enough that it probably offers the best method at present for forecasting the availability of reserves.[1]

With sands of low permeability, the determination of a true "back-pressure curve" may require that the well be flowed for relatively long times in order that steady state flow may be approached. It is suggested here that the points for the curve be determined by successive tests of long duration. As that part of the curve with which future production will be concerned can be determined with back-pressure higher than the line pressure, long tests may be conducted without wasting gas by producing into the line during each test.

4. The total reserves underlying each well must be known. The error in volume of total reserves will reflect almost directly in the accumulated production curve. If the well has been produced for a relatively long time and the volume-per-pound method has given two or three similar values for the reserves, both this value for the reserves and the relation given in 2 above will probably be dependable.

5. Care must be used in determining average values if a composite curve is to be used for several wells.[2] Properly calculated, however, the error introduced by this method will be entirely negligible, as compared with other probable errors.

6. The effect of deviation of the gas from the perfect gas laws will in some cases give an appreciable error. This is discussed in Part 2.

7. Inaccuracy arising from inter-

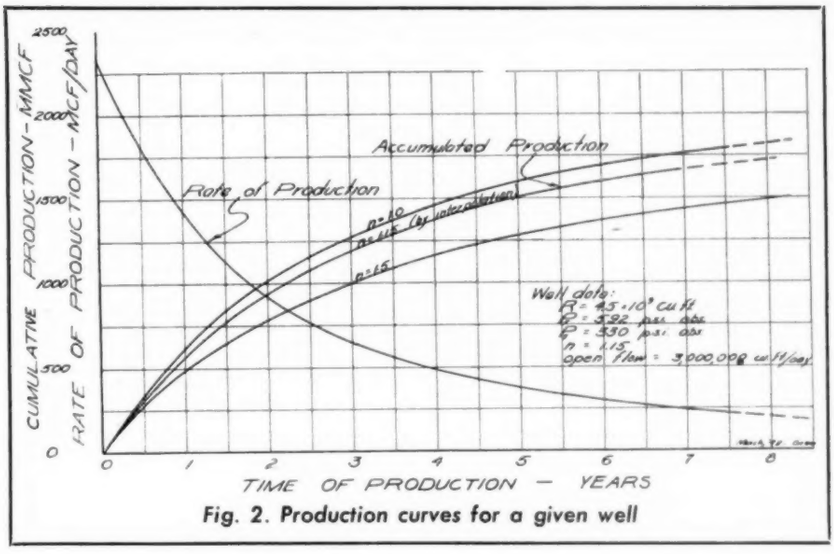


Fig. 2. Production curves for a given well

TABLE I

V (cu. ft.)	$P_f = P_r\left(1 - \frac{V}{R}\right)$ lb. per sq. in.	n=1.0		n=1.5	
		t (days)	t (years)	t (days)	t (years)
225 x 10^6	562	121	0.33	130	0.36
450 x 10^6	533	256	0.70	322	0.88
562 x 10^6	518	331	0.91	443	1.22
750 x 10^6	493	467	1.28	673	1.84
1125 x 10^6	444	882	2.42	1390	3.71
1250 x 10^6	427	1060	2.91	1780	4.88
1350 x 10^6	415	1222	3.35	2110	5.78
1500 x 10^6	395	1548	4.24	3030	8.3
1800 x 10^6	355	2760	7.55	....	....

*From the "back-pressure curve" this is seen to be at a value of $P_f^2 - P_g^2$ equal to 65,000; or P_f equals 416.

$\left(\frac{592 - 416}{592}\right)(4.5 \times 10^9) = 1.34 \times 10^9$.

polating for the curve. This is probably small compared to the effect of error in the value for total reserves and the deviation from the production rate as given by the "back-pressure curve."

Two, three, and four above will be the chief sources of error, and the accuracy of the method is dependent on them.

PART 2

The effect of deviation of gas from the ideal gas laws in calculating production curves for wells producing against a constant back-pressure.

It has been shown that the rate of production of gas from a well will vary as some function of $P_f^2 - P_s^2$. For an equal difference, $P_f - P_s$, over various ranges of pressures, the quantity, $P_f^2 - P_s^2$, increases with an increase in P_f and P_s. As a result, in producing wells that have high pressures the back-pressure maintained must be proportionately closer to the formation pressure in order that the rate of flow be kept low enough to be consistent with conservation measures. The back-pressure must be constantly lowered as cumulative production increases and the formation pressure drops. Because of this, wells with high pressures will not be produced for a very long period of time at the same back-pressure. The wells that will be produced in the manner with which this article is concerned then, will just be those with relatively low reservoir pressures, and the deviation from the gas laws need be considered only over this same low-pressure range. The exact limit of the higher pressures that will be encountered will depend on sand conditions, but will not exceed 1000 lb. per sq. in. formation pressure for most cases.

The fact that deviation of the gas at the pressures that will be encountered may be appreciable is evident from an inspection of the relation of the deviation factor, Z, to the pseudo-reduced pressure of the gas (after George Granger Brown). Fig. 3 shows this relationship for two pseudo-reduced temperatures. From the limited range of pseudo-critical pressures for natural gases (650 to 680 lb. per sq. in. abs. for most gases) and the resulting pseudo-reduced pressures, it is apparent that pressures near 1000 lb. per sq. in. will lead to compressibility factors as low as 0.4 (a deviation of 60 percent) for low pseudo-reduced temperatures. Such extreme deviations are probably not very common, but by disregarding the deviation an error that will amount to as much as all the other total errors combined is possible with a great many gases and conditions of reservoir temperature and pressure that are often found.

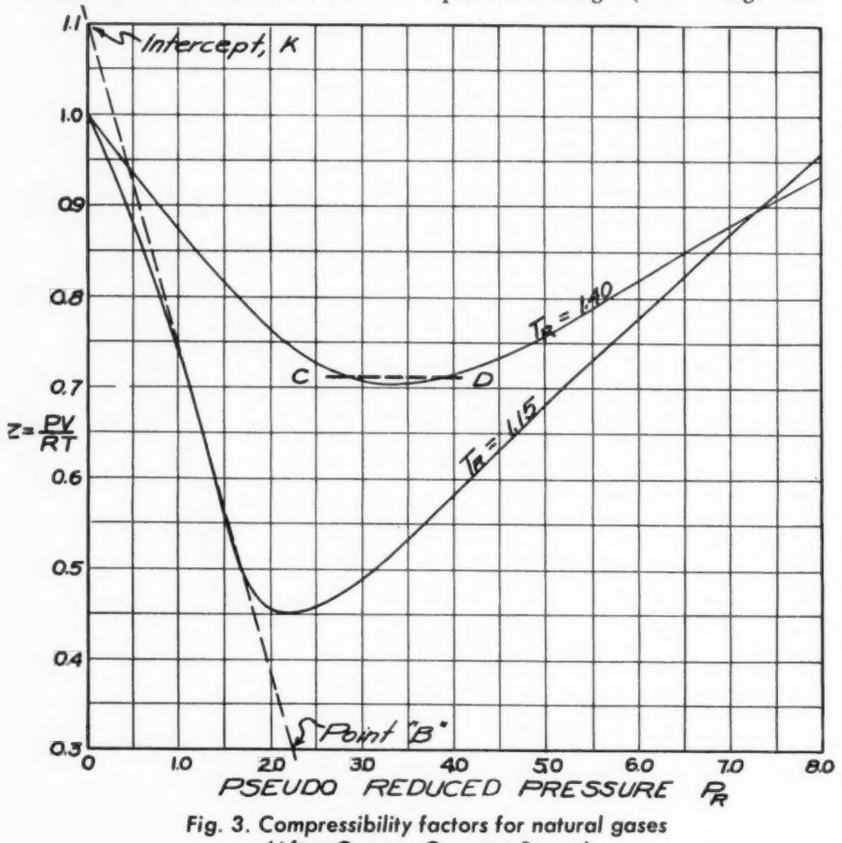


Fig. 3. Compressibility factors for natural gases (After George Granger Brown)

It is possible to determine whether deviation from the gas laws will have a marked effect on the calculated curve for any given condition from a preliminary inspection of the range of values covered by the compressibility factor for the range of pressures concerned. The factors that govern this are described below.

The relation of volume of gas produced to reservoir pressures can be expressed as:

$$V = R\left(1 - \frac{Z_r P_f}{Z_f P_r}\right) \quad \text{. . equation (14)}\dagger$$

Z_r = deviation at P_r

Z_f = deviation at P_f

From this expression it is apparent that the effect on the calculated production curve of the "super-compressibility" of a gas is not dependent on the **amount** of deviation, but on the **change** in value of the deviation factor as the pressure varies from P_r to P_f. This same principle applies to the "volume-per-pound" method of calculating reserves. For example, consider the effect of deviation for a gas under conditions in which T_R equals 1.40 (see Fig. 3). At a pseudo-reduced pressure range of 3.0 to 4.0 the effect will be practically nil, although the compressibility factor is about 0.7 (line CD). For any other pressure range in which the actual amount of deviation is less, the error introduced by omitting the correction for deviation may be very large.

It can also be seen from equation (14) that although the value of V is dependent on the ratio of the deviation factors at the two pressures considered, it is not directly proportional to it. The effect is far more marked than that. For most of the pressure ranges that will be encountered in the manner of production with which this article is concerned, P_f will be nearly as large as P_r, at least during the time when the accumulated production is small. The ratio P_f/P_r is then large compared to the difference, $1 - Z_r P_f / Z_f P_r$. A "percentage difference" in Z_r and Z_f will not reflect directly in the value of V, but will be magnified considerably. It is quite possible that a ratio of Z_r/Z_f, which equals 0.92, and might infer an error of 8 percent on first consideration, actually to result in an error of 70 percent in the value of V. The same applies to the "volume-per-pound" method of calculating reserves.

Because of the relations described it may be necessary at times to determine the effect of deviation of gases from the ideal gas laws in predicting production curves. A consideration of this effect will be given in the next installment to be published in an early issue.

†This follows from PV = ZnRT applied to pressure drop due to gas withdrawal from a reservoir of constant volume.

☆ ☆ ☆

A New Conception of Acidizing

☆ Influence of pumping time and injection with fluid loads on channel or crevice enlargement in respect to rate of reaction

Exclusive

PART 1

by C. E. Clason

Superintendent Acidizing, Halliburton Oil Well Cementing Company

THE purpose of acidizing is, in most cases, to increase the production of oil or gas by increasing the permeability of the pay formation. This is done by removing the soluble parts of the formation with acid.

Before acidizing, certain preliminary work is necessary. The oil is tested for its emulsion-forming properties with plain acid; cores are examined, where possible, to determine permeability and porosity; if not known, the solubility of the pay is tested to determine the possibilities of acid to increase the permeability or restore it if impaired by mud, silt, or paraffin deposits. The drilling log or core examination may indicate whether selective acidizing is advisable; if advisable, it may demand the use of special tools that direct the flow of acid into one or more places in the formation.

Proper technique in acidizing depends on efficient operation of equipment for speed and volume. In addition to a knowledge of subsurface conditions in the field and in the well itself, close attention to motors, pumps, connections, and all mechanical details on the job is essential.

A well may be unable to produce oil at maximum capacity because the pay formations have been mudded-off when the well was drilled or gun-perforated, or because of the cement being in the wrong place. When such conditions are encountered there are ways of overcoming them by the use of acid and hydraulic jet guns. Old pumping wells whose pay sand is plugged with paraffin may be revived and oil production increased by pumping hot distillate with a jet gun to remove the deposit of paraffin obstructing flow.

Commercial muriatic acid, or hydrochloric acid, a solution of hydrogen chloride gas in water, is used in acidizing wells. The greater the concentration of hydrogen chloride gas, the heavier the acid solution. Commercial muriatic acid has a gravity of 20 deg. Baumé on the scale heavier than water, or a specific gravity of 1.16, weighs 9.66 lb. per gal., and contains 31.45 percent hydrochloric acid (HCl) by weight at 60 deg. F. Acid of this strength, or concentration, is unsuitable for well-treating because of its highly corrosive action on metals regardless of the care taken to prevent it. Acid is therefore diluted with water to form a 15 percent solution, which is the concentration ordinarily used in practice and known as treating acid.

C. E. CLASON

for 20 years was with Dow Chemical Company, Midland, Michigan, as analytical chemist and plant superintendent, where he did inorganic research work—In the summer of 1932 he was placed in the Acidizing Department, having charge of the Michigan district — Was transferred to Kansas in January, 1933, as district manager to pioneer the work there—In May, 1935, entered the employ of the Halliburton Oil Well Cementing Company, as superintendent of the Acid Division.

The reaction between acid and calcium carbonate (limestone) expressed chemically, is:

$$2\,HCl + CaCO_3 \rightarrow CaCl_2 + CO_2 + H_2O$$

According to this chemical equation, 1000 gal. of 15 percent HCl would react with 1850 lb. of $CaCO_3$, forming 331 lb. (about 41 gal.) of water, resulting in a solution of calcium chloride of 20.4 percent concentration and 1.185 specific gravity, and 6990 cu. ft.[1] of carbon dioxide gas. If the pressure at the bottom of the well is greater than 800 lb. per sq. in., all the carbon dioxide will be in solution in the liquid product of the reaction. This gas in solution would be liberated due to the decreasing pressure as the fluid rose to the surface. By holding a pressure of 800 lb. or more when pumping acid into the well, the carbon dioxide gas is held in solution, the release of pressure later will cause the carbon dioxide gas to come out of solution and thus aid in expelling the spent acid from the well.

When the carbon dioxide is entrapped under pressure in the well, the rate of chemical reaction is retarded. This rate of reaction can be further retarded by the addition to the acid of a chemical, which also holds gypsum in the solution after the acid has been spent on the limestone.

In dolomitic limestones, which contain a mixture of calcium and magnesium carbonates, the chemical reaction proceeds in the same manner as in pure limestones (those containing only calcium carbonate), but at a somewhat slower rate, forming a mixture of calcium and magnesium chlorides.

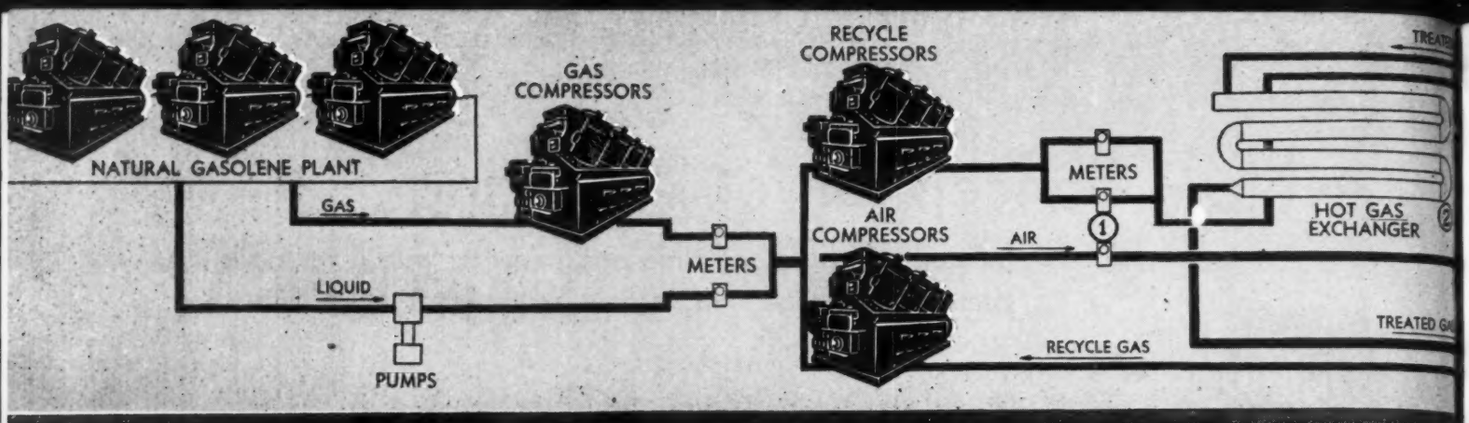
A fuller knowledge of the rate of reaction under varying conditions, together with the results obtained from years of experience, has led to the practice of injecting acid at a faster rate under low pressure, and of unloading the acid from the formation as rapidly as possible after a treatment.

The volume of acid per shot, or treatment, usually has been determined by the operator and is based on opinions influenced by local practice, the thickness and extent of the formation to be treated, and the cost. The practice of dividing the acid into several shots has grown steadily since 1934. A small amount of acid is first used as a "clean-up," followed by one or more larger shots in succession to obtain penetration and greater permeability. In oil wells these treatments may follow in close succession on the same day, or the well may be produced for several weeks between shots to obtain more data on the actual necessity for additional acid. The volume of flushing oil or water should always be such that no acid is left in the tubing or casing.

The correct speed in placing acid in the formation is necessary for the best

(Continued on Page 55)

[1]This is the volume the gas would occupy under standard conditions of temperature and pressure.



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(Continued from Page 51)

results. On some large gallonage jobs, two or more pumps are used simultaneously. In all types of well-treating, a rate of injection should be maintained that not only reduces the possibility of pipe corrosion but results also in penetration of the column of acid before it is entirely spent.

The question of how far acid penetrates a given formation often arises in the field. Thousands of wells have been acidized without particular attention being paid to this important point, so its discussion here may be of value, for it has a bearing on methods of washing a formation in gas-well treatments. Most of the data that follow, particularly that with respect to Fig. 4, have as their basis the researches of Muskat.[2]

Assumptions regarding porosity must be made unless accurate knowledge of the formation is available. The two sets of curves, Figs. 1 and 2, give some idea of the distance penetrated by different volumes of acid in strata of known thickness and of assumed uniform permeability. The two curves in Fig. 1 show the acid penetration for two different porosities, 10 percent and 20 percent respectively, As the porosity of most formations will be close to one or the other of these curves, the probable penetration can be approximated. From these charts the approximate penetration of a given volume of acid can be quickly found when the thickness and porosity of the permeable pay formation are known. If several strata of known permeability are subjected to simultaneous treatment, the most permeable should be considered as receiving the acid. It should also be noted that a formation may contain channels that depart from uniform permeability in the accepted sense.

The greatest increase in production by acidizing is obtained by enlargement of long channels or horizontal radial fractures. To the enlargement of such channels can be attributed the overwhelming results sometimes obtained.

New or old wells may be mudded-off and normal permeability impaired. Acidizing not only will restore the permeability to normal but may increase it near the face of the well bore and at a great distance therefrom, and a corresponding increase in production obtained. Some deep wells have highly permeable strata of soft limestone or dolomite that absorb drilling mud in great volume. In formation of this character, especially if of great thickness, a large volume of acid is necessary to restore the permeability of the formation to normal.

It will be noted from Figs. 1 and 2 that even when large volumes of acid are used, the permeability is increased only a relatively short distance from the bore of a well, the permeable pay formation of which is assumed to have a uniform porosity and permeability.

Muskat[2] has shown that to double the rate of production of a well without increasing the normal permeability, its diameter would have to be increased forty-fold; that is, a 6-in. hole, for example, would have to be increased to 22 ft. in diameter. How much the rate of production is increased in acidizing will depend on the increase in permeability and the resulting net drop in formation pressure near the well bore. The formation pressure in the well increases outward and away from the well bore until it reaches that of the rock pressure.

Increases in rate of production by acidizing vary with the effective porosity[3] in different formations. This is illustrated by the fact that a 2000-gal. treatment in one type of formation will sometimes accomplish as much as a 5000-gal. treatment in another, assum-

[2]Flow of Homogeneous Fluids, by Morris Muskat, McGraw-Hill Book Company, New York, New York.

[3]Effective porosity refers only to that of the pore space that is available to fluid flow, p. 113 "Flow by Homogeneous Fluids," by M. Muskat.

Fig. 1. Relationship between radius of penetration and quantity of acid used for pays of 10 percent and 20 percent porosity

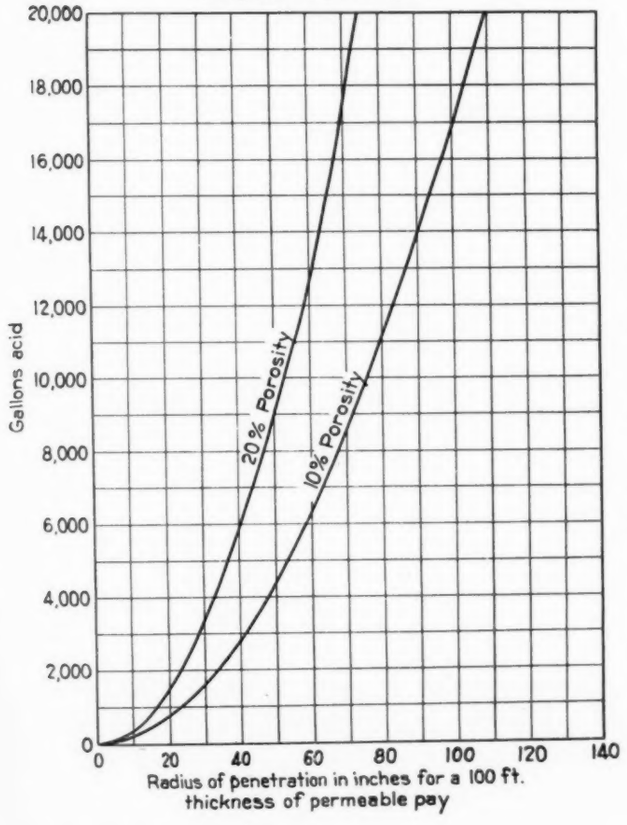
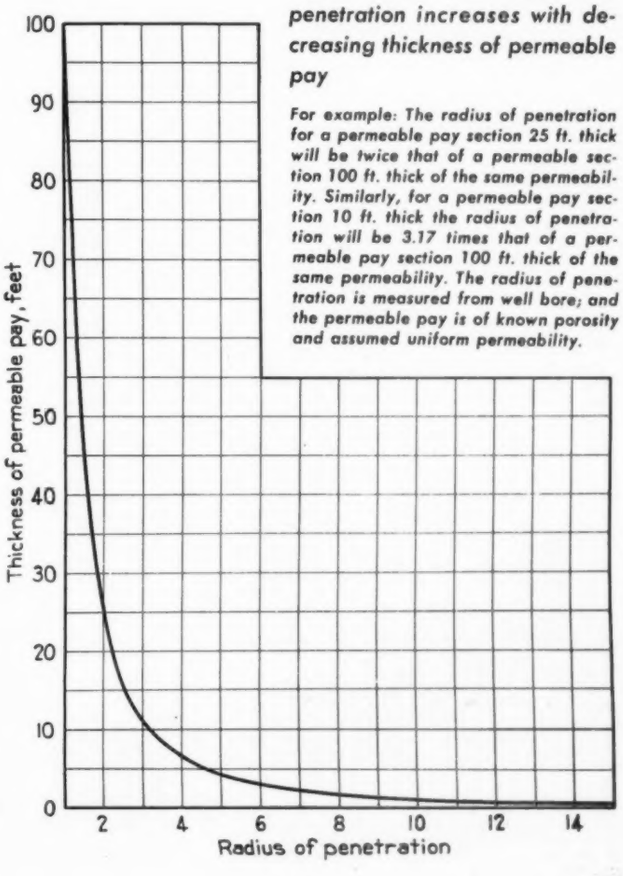


Fig. 2. Shows how radius of penetration increases with decreasing thickness of permeable pay

***For example:** The radius of penetration for a permeable pay section 25 ft. thick will be twice that of a permeable section 100 ft. thick of the same permeability. Similarly, for a permeable pay section 10 ft. thick the radius of penetration will be 3.17 times that of a permeable pay section 100 ft. thick of the same permeability. The radius of penetration is measured from well bore; and the permeable pay is of known porosity and assumed uniform permeability.*



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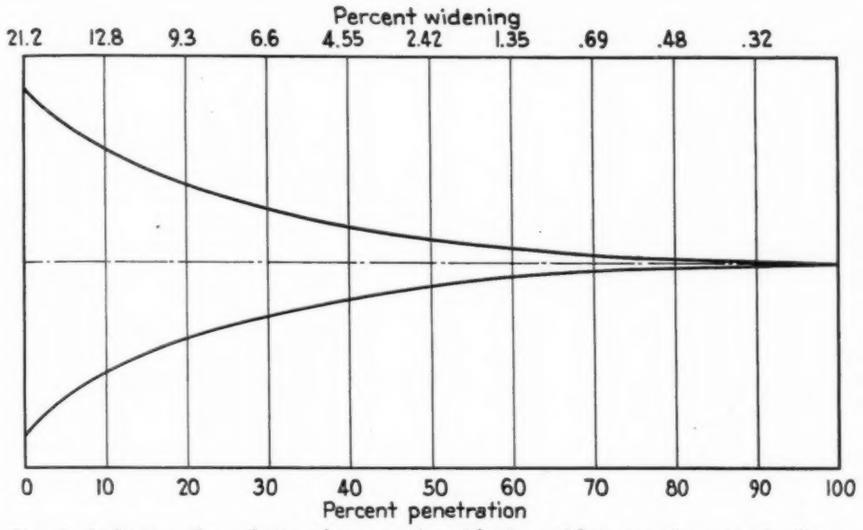


Fig. 3. Indicates the relative decrease in widening with increasing penetration for a pumping time of 50 minutes

ing both formations have the same relative thickness of permeable pay. The formation pressure may also be a governing factor affecting the increase in rate of production, for it is apparent that the higher the formation pressure the greater the pressure drop possible by acidizing for increasing the velocity of flow.

When the rate of chemical reaction of the acid under pressure is known, the action of acid in enlarging a fracture can be determined to a certain extent. This rate is 40 minutes for limestone and 50 minutes for dolomite for pressures greater than 800 lb. per sq. in. (see Fig. 5). It has been customary to assume that the dissolving action is uniform throughout that part of the formation penetrated by the acid. This assumption fails to take into account the greater travel and lapsed time necessary for the acid to reach the formation at points remote from the well bore. The dissolving action will be greater near the bore of the well, where more acid passes through a fracture, than at the extreme end of travel, where the acid may be entirely spent at the moment of shutdown.

Experiments made to determine the rate of reaction in limestone of a density about halfway between that of dolomite and fast-acting limestone, assuming a definite pumping time and an equal reaction time, indicate the amount crevice enlargment in 50 minutes pumping time would be as shown in Fig. 3. Amounts of limestone removed, indicated as percent widening in Fig. 3, are shown for a single horizontal crevice. Acid is spent gradually as it penetrates the formation and accounts for the gradual decrease in percent widening of crevice as the radius of penetration increases. Fig. 3 is intended to be only a graphic representation of the relative widening of a crevice less enlargement at a distance; that is, the radius of penetration is less and the widening of the channels at the bore of the well is greater. Spent acid can be forced ahead before the total volume is in the formation. Faster pumping results in less time of contact near the well bore and correspondingly less fracture or channel enlargement. The size of the opening at the well bore is a limiting factor in flowing capacity. Maximum efficiency of the acid is obtained by the greatest widening at the well bore accompanied by reaction of acid to the limit of penetration. This is accomplished by making the injection time equal the reaction time.

Crevice enlargement in this manner makes efficient use of the effective permeability of the formation. The pressure drop increases as the well bore is approached. If the removal of limestone approached uniformity by faster pumping, the smaller height of the crevice at the well bore would act as a choke and restrict the flow from the crevice and its tributaries. Correct pumping speed during acidizing is designed to obtain optimum flow and complete reaction and penetration of the acid in the formation being treated. This is discussed at greater length under "Acidizing with Fluid Loads," in which the maximum widening possible from correct time of injection is taken as 100 percent and the effects of varying injection rates shown with respect to production rates.

Editor's Note: This article will be continued in an early issue.

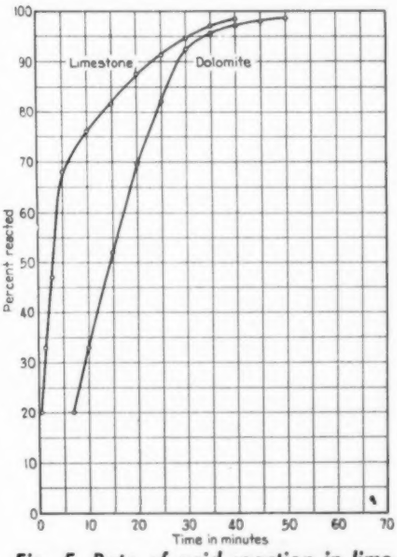
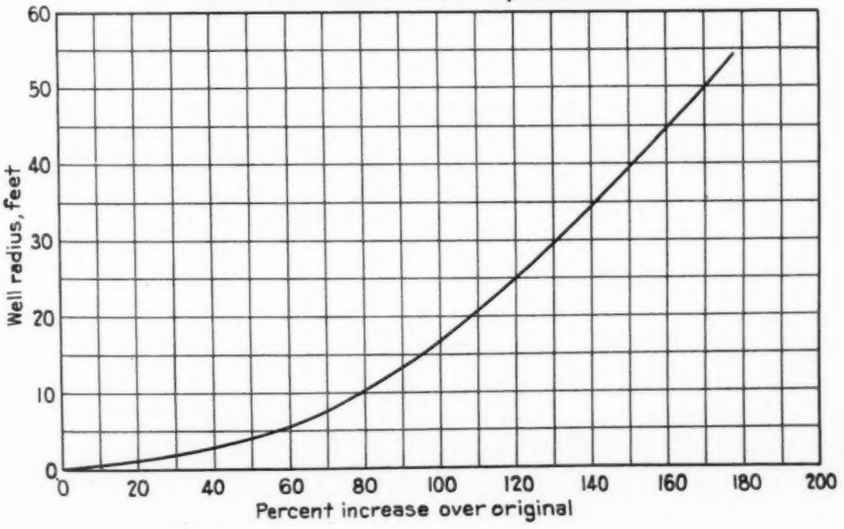


Fig. 5. Rate of acid reaction in limestone and in dolomite under pressure

Fig. 4. Percent increase in production if normal permeability is increased 10 times for different radii of penetration



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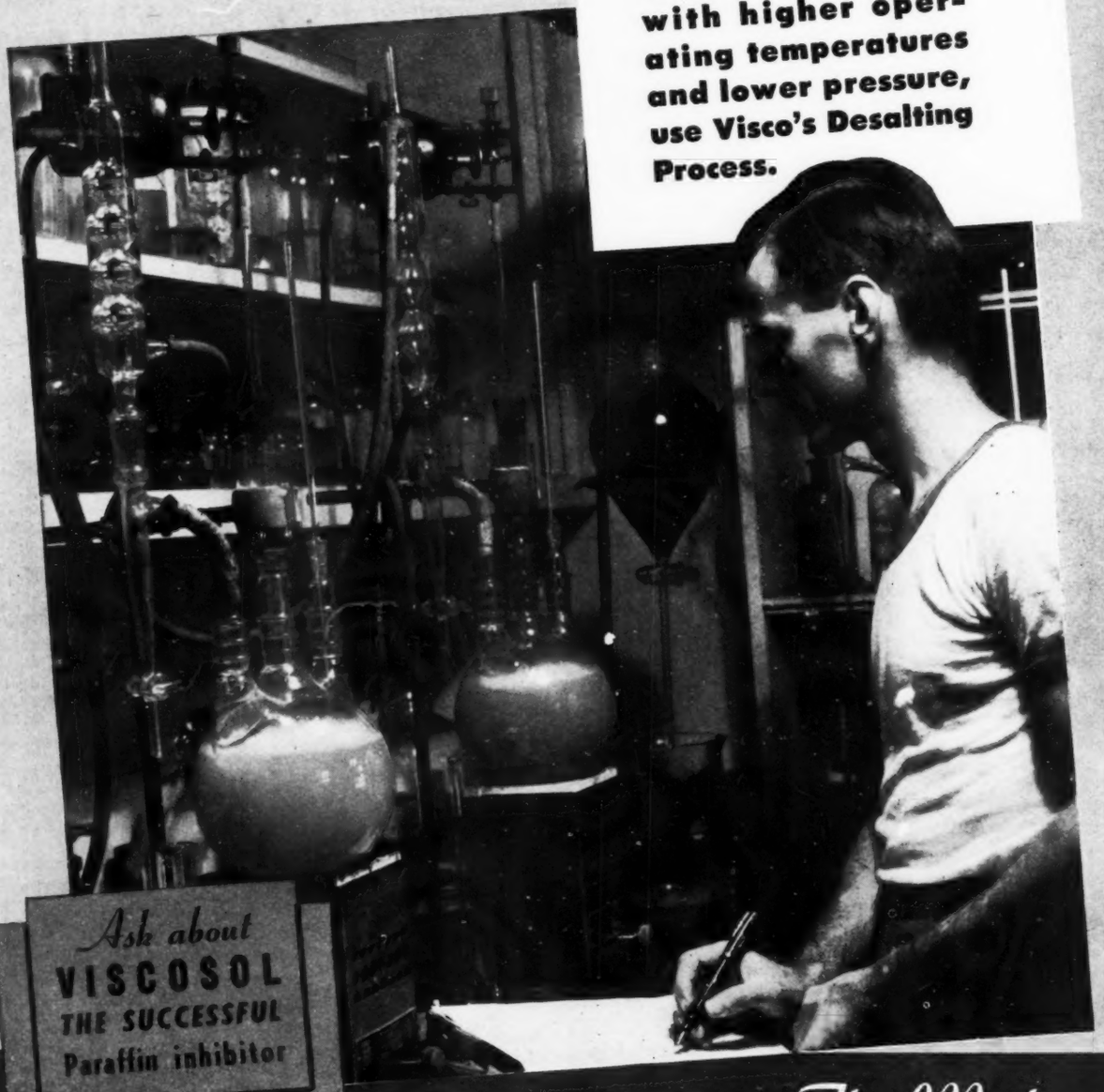

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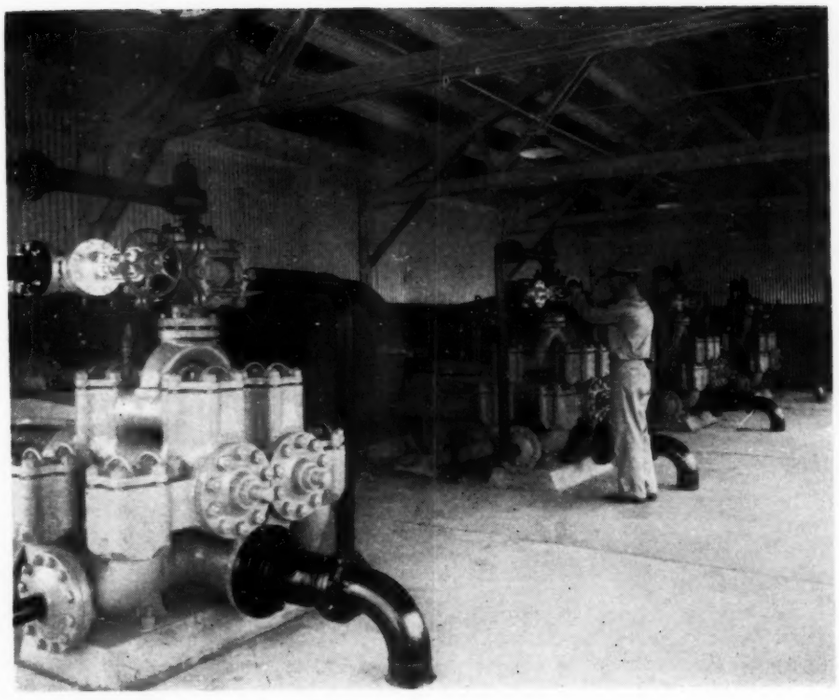


View of pump room showing built-up wooden trusses and firewall installation that runs continuously to the top of saw-tooth roof over engine room. Firewall above eave of truss is partly interrupted by ventilating louvers

PETROLEUM ENGINEER Exclusive Feature

Reversing Flow Through Pipe-Line System

☆ Mechanical features involved in revamping 224-mile line of Pan American Pipe Line Company

by Frank H. Love
Managing Editor

TO permit active participation in the war emergency effort to deliver needed refined petroleum products and crude oil to the East Coast, it was necessary for Pan American Pipe Line Company to reverse the direction of flow in a 224-mile, 12-in. crude oil line between Texas City and Longview, Texas, and erect a terminal pump station at the former point, a booster station at Henderson, Texas, and revamp its main line station manifolds. Heater oil and light crude are being delivered at Longview to the War Emergency Pipelines' system, and gasoline and kerosine enter the line of the Bayou Pipe Line System at Baytown. The Bayou system, in turn, connects at Baton Rouge, Louisiana, with the Plantation Pipe Line, laid originally to

Engine room showing four automotive-type engines that are connected to pumps by V-belts through firewall

Greensboro, North Carolina, and recently extended to Richmond, Virginia.

Convert Slush Pumps

By directive from the Petroleum Administrator for War, Pan American's Texas City-Longview line serves as a carrier and transports not only products from the company's refinery at Texas City, but also products from the refineries of Humble Oil and Refining Company, Sinclair Refining Company, Crown Central Petroleum Corporation, Republic Oil and Refining Company, and Maritime Oil Company.

Because they were the most readily available high-pressure pumps, four converted slush pumps were installed at the Texas City Station.

The pumps are mounted on concrete foundations rather than the customary practice in drilling operations of mounting them on heavy skids. Due to soil conditions at the Texas City Station site, and the vibration caused by the reciprocating motion of the pumps, it was decided to limit the bearing pressure of the pump foundations to approximately 600 lb. per sq. ft.

In order to convert the pumps to pipe-line service, it was necessary to replace the standard valves used for mud service with bronze valves and seats, and replace the rubber pistons with metallic pistons equipped with snap rings, which would be satisfactory when operating in a non-lubricating liquid.

Each pump is equipped with an individual harp-type bypass, which is piped from the side of the pump's discharge head into one end of the pump's suction manifold barrel. The bypass piping is arranged to permit the shear type relief valve, which is situated on top of the pump's discharge head, to utilize the bypass as a relief valve discharge line, thus utilizing a single line for a dual purpose, and at the same time making a compact piping job.

The four 220-hp. gas engines are mounted on "H" beams, which are anchored in a concrete foundation. The H beams are slotted to allow movement of the engine base bolts to facilitate movement of the engines for loosening or tightening of the belts. The movement of the engines is accomplished by means of turnbuckles attached to the engine base and anchored in the concrete foundation.

Automatic Cooling System

A cooling system incorporating a cooling tower is used for the engines. Cold water is received from the tower through a 4-in. header running parallel to the arrangement of the engines. Each engine takes its requirement of water through a 2-in. feed line connected to the main 4-in. cold water header. A bypass system at each engine insures proper cooling water temperatures at all times. The water circulating pumps on the engines deliver the warm water overhead to a 4-in. header, which discharges into a 10-in. by 14-in. vent tank. A motor-driven centrifugal pump, automatically controlled by the water level in the vent tank, delivers the required amount of water over the cooling tower. The system is automatic inasmuch as the thermostatic bypass on the engines determines the water to the vent tank and the water level control in the vent tank determines the quantity of water over the tower.

Gas used for fuel in the engines is supplied to the station at a pressure of 600 lb. per sq. in. As the engines use fuel at a pressure of approximately 6 oz., the 600-lb. pressure is reduced to engine requirements in three stages. The first stage reduces the pressure from 600 to 150 lb., at which pressure the gas enters a second regulator and is further reduced to 30 lb. The second regulator discharges the 30-lb. gas into a combination reservoir and trap. The reservoir is made of 8-in. pipe approximately 60 ft. long, and is installed with a grade sufficient to make any condensate drainage collect at the low end of the reservoir. Suitable drains are installed at the low point for removal of condensate. Thirty lb. to 6 oz. regulators are installed at the engine in the 2-in. supply lines from the gas reservoir. This design insures an adequate supply of gas with an even pressure to any one engine, regardless of the operation of the other engines.

Floating Engine Exhausts

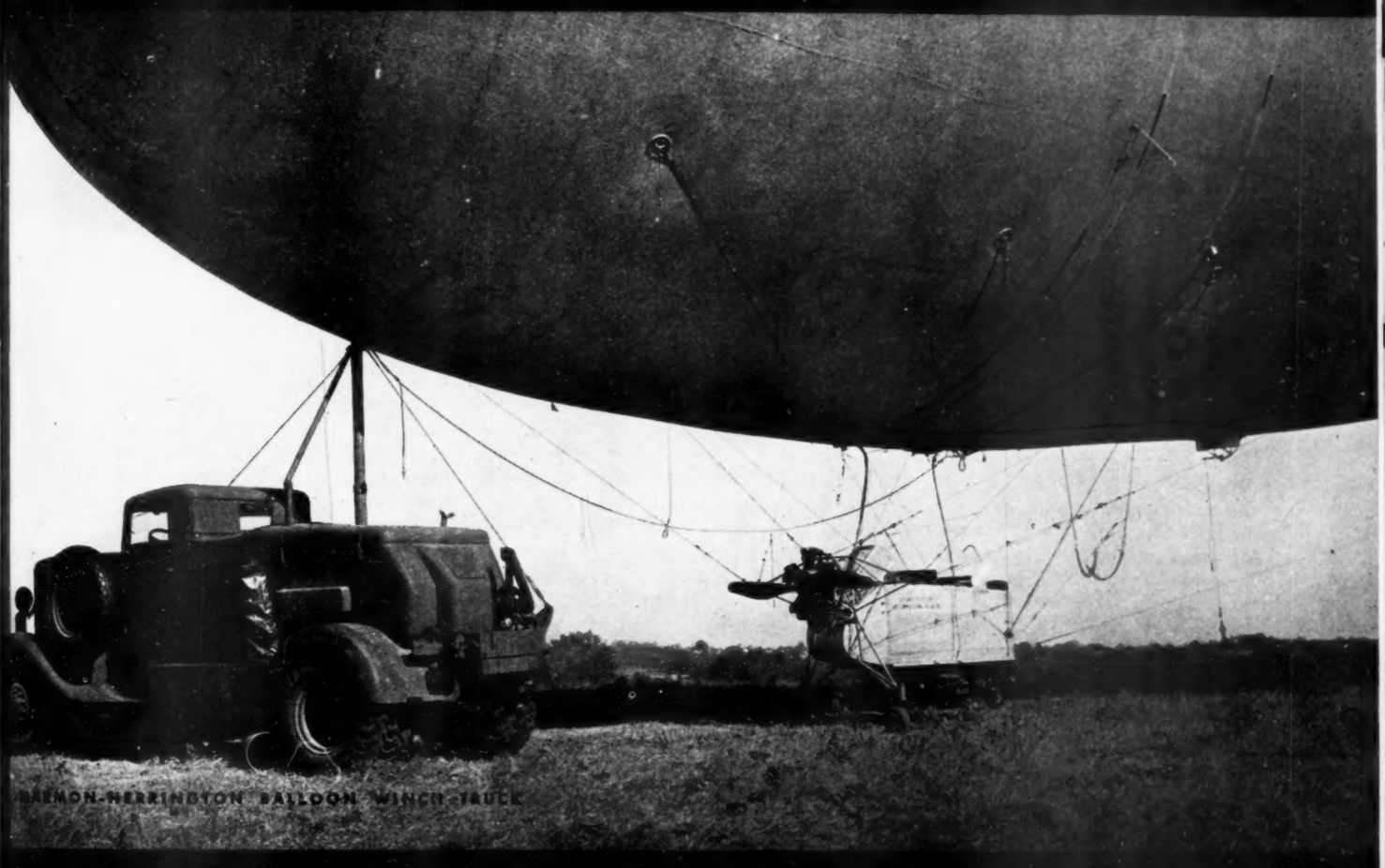
The exhaust piping from the engines is unusual in that it was decided to build a floating one-piece exhaust from each engine to the outside of the engine room. It was necessary to make a full floating system or place a flexible joint in the exhaust pipe to permit movement of the engines for belt adjustments. The exhaust pipes rise overhead approximately 2 ft. above the top of the engines, then ell and run approximately 15 ft. through the wall of the engine room to the outside of the building. The exhaust pipes are suspended so that all strain on the exhaust manifolds is eliminated and at the same time they are free to move, when belt adjusting is necessary.

Second-hand material was used when available, to the end that the minimum amount of new, critical material would be expended in building the station. An accompanying picture of the building shows the saw-tooth design adopted to avoid need of steel framework and, at the same time, provide satisfactory coverage and ventilation for the pumps and engines. In planning the wooden building it was broken up into segments to permit utilization of such lumber as was available.

The Henderson Station has two 250-hp., 3-stage, motor-driven, centrifugal pumps capable of delivering 50,000 bbl. per day at 400-lb. pressure. The station building is of wooden construction, covered with corrugated iron, and consists of a small office and pump room. All pumping equipment, valves, and fittings were second-hand, thus saving a maximum of critical materials in the construction.

View of the west side of station, office on left, auxiliary room right. Truss and saw-tooth type roof construction permits continuous and tight firewall installation between engines and pumps. Face of saw-tooth has louvers for ventilation of engines, which are installed underneath

USERS WILL *Demand More of Trucks*



AFTER THE WAR

Never before have automotive vehicles been called upon to render the services they are rendering to our United Nations cause in this war. The difficulties encountered in transporting men and materiel across desert and plain, over mountains and through jungle marshes have created an appreciation of the *All-Wheel-Drive* principle of propulsion, which will influence automotive design and construction for all time. No longer will truck users be content with vehicles that lose their power and effectiveness once they leave firm footing. The millions of men who have experienced the startlingly different performance of *All-Wheel-Drive* in military service, will see to that.

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Inspection and Analysis Of Formation Samples

PETROLEUM ENGINEER Exclusive Feature

☆ Determination of fluid content and permeability of core samples by quantitative laboratory tests

by Lester C. Uren

Professor of Petroleum Engineering, University of California

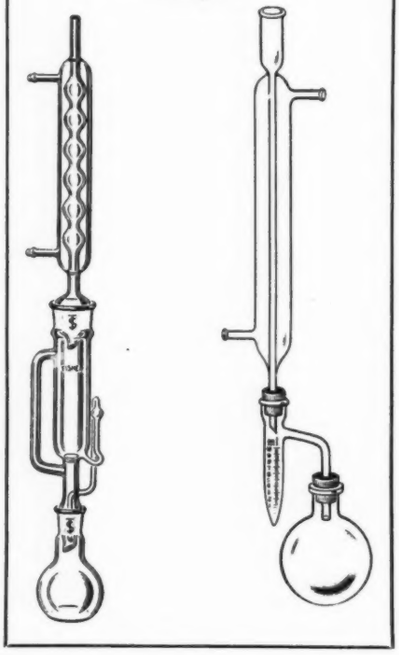
THE first installment of this series of articles, reviewing methods of inspection and analysis of formation samples obtained in the course of drilling wells, appeared in the April, 1943, issue of *The Petroleum Engineer*. In this initial article were outlined the methods of taking samples, of inspecting them at the well, and preparing them for shipment and testing in the laboratory. In the present article, explanation is offered of the methods of making permeability tests and of determining the nature of the fluid content. Before tests to determine lithologic properties can be made, the selected sample must be dressed to size and extracted or subjected to heat treatment to remove contained fluids and soluble residues. A separate portion of the original sample is preserved for determination of oil and water content.

Extraction of fluids from core samples prior to determination of porosity and permeability. Porosity and permeability are properties of rocks that depend upon lithologic structure. Any liquid or foreign residues occupying the pore spaces or adhering to the mineral surfaces, will operate to reduce the apparent porosity and permeability. Accordingly, such foreign substances should be removed before tests of these properties are made in the laboratory. This may be accomplished by extraction with appropriate solvents or by retorting at a temperature sufficiently high to vaporize the interstitial fluids.

The liquids ordinarily present are oil and water. Foreign solid substances may be paraffinic or asphaltic residues or soluble salts resulting from evaporation of water and volatile hydrocarbon oils. The Soxhlet apparatus affords a convenient means of conducting an extraction operation. (See Fig. 1). The specimen to be treated is suspended in a porous thimble, in a glass tube into which solvent continually drains from a condenser and from which the contaminated solvent is periodically siphoned into the distilling flask below. Heat applied to the distilling flask affords a continuous supply of fresh solvent in vapor form to the condenser. The extraction process is thus continuous and may extend over a period of several hours during which impurities leached from the test specimen gradually accumulate in the distilling flask.

No one solvent is entirely satisfactory for all purposes. Oil and oil residues may be extracted with carbon tetrachloride, carbon bisulphide, benzol, benzene, cleaners' naphtha, pentane, xylene, and similar solvents of hydrocarbon or related types, but for complete removal of water, acetone, butanol, or ethylene dichloride are preferable. Two or more different solvents may be used in succession. Thus, the specimen may first be extracted with benzene to remove crude petroleum and petroleum residues, then with acetone to remove water, and finally with pentane to displace the acetone and facilitate rapid drying. Acetone is a convenient solvent, being miscible both with hydrocarbon oils and water, and comparatively inexpensive. The solvent used must not alter the mineral structure of the specimen in any way and yet must have adequate solvent power for the fluids and soluble residues that may be present. Some solvents, such as carbon disulphide, pentane, and benzene, present serious fire and explosion hazards. Carbon tetrachloride has the great advantage of non-inflammability.

Fig. 1 (left). Soxhlet extraction apparatus. Fig. 2 (right). Apparatus for distilling water from formation samples



After extraction, the specimen should be heated for a time and at a temperature sufficient to evaporate all solvent from its pores. This drying of the specimen may be done in a thermostatically-controlled oven maintained at a temperature below 210°F. It is important that temperatures much in excess of this be avoided, or clays and other hydrated minerals present may be altered by loss of their water of crystallition.

Determination of fluid content and properties of fluids present in core samples. It is often required to determine quantitatively, the gross fluid content of a core sample. This may be done by weighing the specimen before and after extraction, as described above. The loss in weight after extraction is considered to be the weight of water and oil present in the pore spaces. Later, when the percentage porosity has been determined, we may assume an average density for the contained fluids, and compute the equivalent volume and the "percentage saturation." This is defined as the percentage of the pore space of the specimen occupied by liquids. Ordinary extraction, however, does not distinguish between "water saturation" and "oil saturation."

Water saturation may be determined by placing the sample in a desiccated Soxhlet thimble, weighing and distil-

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When the program calling for unprecedented quantities of planes, tanks, ships, trucks, etc., was outlined, it was evident that the oil to operate these vehicles of war would be just as essential as the vehicles themselves. Inasmuch as we were wholly engaged in the manufacture of indispensable tools for the oil producing industry, we were already an important cog in this emergency program.

The task before us, therefore, was to continue furnishing these tools and to devote whatever additional capacity we had or could develop to other vital war production.

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Like other branches of industry, we have had our problems over machine tools, materials, technical procedures, and skilled labor. As we have solved these problems in the past, we expect to solve new ones as they arise.

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ling in an apparatus such as that prescribed by the American Society for Testing Materials for the determination of water in oil. (See Fig. 2). Submerged in a suitable solvent, such as xylene, the sample is heated in the distilling flask until the water is driven off and accumulated in the graduated receiving tube, where its volume may be directly observed. The percentage water saturation may then be computed in terms of the volume of the pore space as determined by quantitative methods.

After extraction of the water, the sample is transferred to a Soxhlet extractor, and the residual oil removed. After complete extraction of contained fluids and drying of the sample, the overall loss of weight is determined. The original weight of the sample, minus the weight of water removed, minus the final weight of the extracted and dried sample, is the weight of the oil content of the sample. If the density of the oil can then be determined, its volume can be computed and the percentage oil saturation calculated.

A more rapid, though somewhat less accurate, method of determining oil and water saturation involves heating a separate sample of the core than that selected for porosity and permeability determination, in a retort, condensing the oil and water vapors driven off, and directly measuring their volumes in a graduated burette. (See Fig. 3). The retort is maintained at a temperature of 350°F. for about 40 min. while the water and all but the heaviest fractions of the oil are driven off. The retort temperature is then increased to about 1100°F. for at least 20 min. to drive out all residual hydrocarbons. The sample is carefully weighed before sealing it in the retort. Preferably, about 150 gms. is broken into pieces about 0.5 cm. in size and, after retorting, the weight is again determined. Loss of weight is the weight of fluids driven out of the specimen, and is compared with the weight of fluids collected in the graduated burette. The difference is considered to be gas or liquid lost or uncondensed in the process of retorting and an equivalent volume is added to the volume of the fluids condensed and measured. For accurate work, certain corrections must be applied to the observed loss of weight and measured volumes of oil and water condensed, to offset loss of water of crystallization and dissociation of carbonate minerals, as a result of the high temperature applied. Some hydrocarbon residues may be left in the form of coke, particularly if the oil is of low A.P.I. gravity.

Determination of gravity of oil in core samples. It is necessary to know the approximate density of the oil in order to convert gravimetric to volumetric measurements and to determine the percentage oil saturation from loss of weight in extraction or retorting tests. The small amount of residual petroleum left in a core sample affords but a poor basis for determining the gravity of the oil. A better result can generally be had by seeking a sample of the oil directly from the producing horizon with the aid of a formation tester. The properties of the oil procured in a retorting test conducted as described in the foregoing paragraph, however, may be determined with the aid of a small pycnometer. By applying a suitable correction factor to the observed gravity, the probable density of the oil as it exists in the reservoir rock may be estimated. A considerable loss in A.P.I. gravity is suffered by the oil in the process of retorting. Thus, residual oil recovered in retorting may have a gravity of only 20 A.P.I., whereas the gravity of the oil as it exists in the reservoir rock may be 40°. Tests may be made in the apparatus employed in retorting to determine the density loss suffered by a series of crude oils of different gravities. By comparison with such results, assembled in graphic form, the approximate corrected gravity of the oil condensed in the course of a retorting test may be estimated.

The water content of a core sample, as determined by extraction or retorting, may be connate water actually present in the pore spaces of the reservoir rock, or it may be water that has penetrated the core as a result of absorption of drilling fluid. Tests made by cutting cores in the presence of drilling fluids containing chemical reagents that can be identified in the water in the cores, indicate that drilling fluid may displace oil or gas in the outer portions of a core sample, but if the core is of large diameter and test samples are selected from the central portion, such water as is found to be present is likely to be connate water.

Connate water may also be characterized by a high chloride content. Salinity of the connate water in a formation sample may be a matter of interest, inasmuch as resistivity values recorded in electrical logs are influenced thereby. To determine the salinity of the water present in a core, a sample may be selected, crushed to separate the individual grains, and leached with a small amount of fresh water. After filtration of the leaching water from the sample, the filtrate is titrated to determine chloride content.

Determination of permeability of core samples. Permeability is defined as that property of a porous medium that measures its capacity to transmit fluids through its pore spaces. It is inversely proportional to the flow resistance offered by the porous medium.

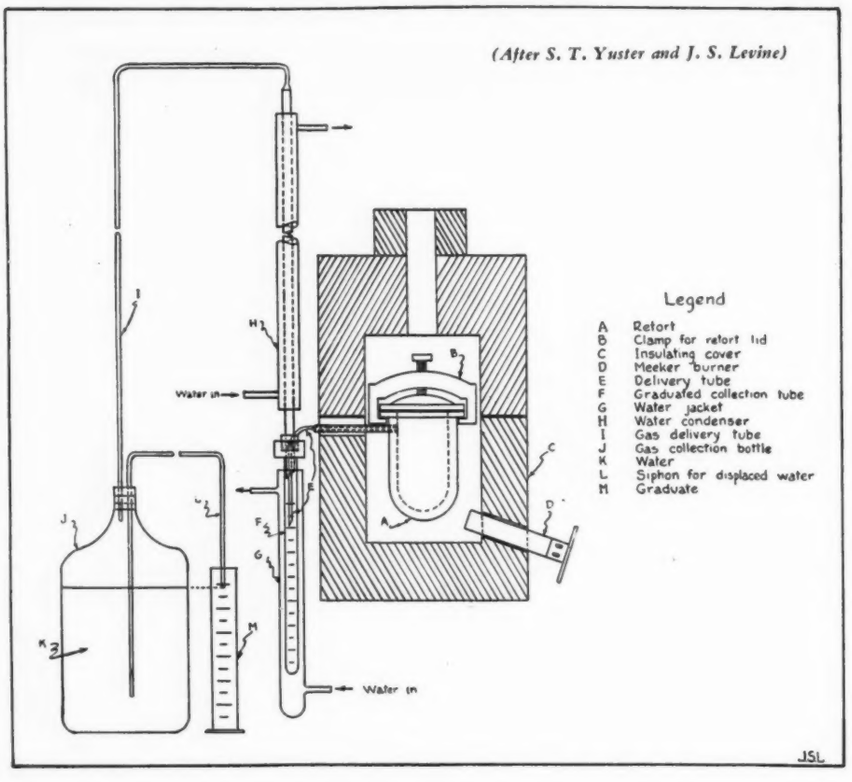

Fig. 3. Arrangement of retorting apparatus for determining oil and water content of formation samples

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THIS SHIP LEAVES BEHIND ★ A Great Future

Important gains to the oil industry will come from our war program

We hear a great deal of talk these days about the great contributions American industry is making to war production. This is understandable . . . because industry HAS contributed a tremendous amount of vital "know how" and brainpower to increasing the effectiveness of our war program. *But have you thought about this other side to the picture?* . . .

Here at Baash-Ross we have been doing important war work since long before Pearl Harbor, making parts for the giant 4-motor bombers that are performing such an outstanding job on our war fronts . . . and equipment for flying boats . . . and equipment for naval combat vessels and merchant ships that are carrying our war to the enemy all over the world. Naturally, we're proud that we are able to contribute our share to the war effort and — although we can't say much about this production without revealing war information — we feel it has been *substantial!*

But there's another, a lesser-talked-about side to this war production picture that we at Baash-Ross think is mighty important. Instead of stressing the contributions industry has made to the war effort, we think even more important are the developments the war effort has made possible in American industry . . . *developments that have bridged in a few months what would normally have taken many years to cover..*

FOR EXAMPLE, this ship you see going down the ways. At the beginning of the war it took 5 to 6 months to build and outfit a ship like this. Today the same job is being done in a *small fraction* of that time. It's the *same* ship, built of the *same* materials, using the *same* fittings. But there is a tremendous difference in the "know how" of the men behind the ship. All along the line — the men who make the fittings, men who make the engines and equipment, and the men who put the ship together — have *all* learned vital speed-up techniques that have cut great slices of time from production operations.

Here at Baash-Ross we are machining a certain large part for this ship that is similar to an oil tool we've been making for years. We thought we knew all the tricks there were in this particular machining operation. But we're frank to state that we have learned more about this machine job in the past few months than we had learned in years before . . . because the pooling of trained minds from MANY *branches of industry has developed a better way of doing the job than any* ONE *group of engineers could alone. As a result, when the war is over, we'll be able to machine this oil tool faster and build it even better than we did before the war, bringing important benefits to you who use it!*

Every ship that goes down the ways . . . every plane that takes to the air . . . every item of war equipment that goes out to the war front leaves behind it a vast fund of newly-discovered improvements, of better techniques for doing the job. And this newly-gained knowledge means a great future for post-war production efficiencies.

Permeability is measured by an arbitrary unit called the "darcy," named after Henry Darcy, a physicist who, in 1856, studied the flow of water through filter beds and proposed an empirical formula that has been found to express accurately the factors that enter into an expression of the pressure loss in flow of fluids through porous media. The Darcy formula may take various forms, depending upon the character of the fluid and the direction of flow. For horizontal flow of a liquid through a porous medium of uniform cross-section, the following formula expresses the relationship of the several factors involved:

$$K = \frac{u\,Q\,L}{A\,(p_1 - p_2)}$$

Here:

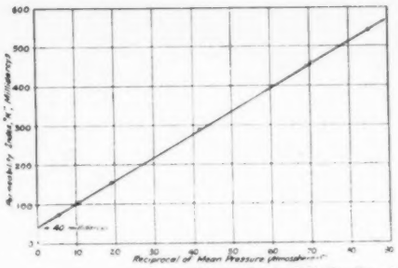
- K = the permeability of the porous medium in darcys,
- u = the viscosity of the fluid in centipoises,
- Q = the volume rate of flow measured in ml. per sec.,
- L = the length of specimen in cm.,
- A = the cross-sectional area of the specimen in a plane perpendicular to direction of flow, in cm.,
- p_1 = the pressure at the up-stream face of the specimen, and
- p_2 = the pressure at the down-stream face.

When a gas is used as the flow medium, Q is the average volume rate of flow at the average pressure existing during flow through the specimen, or:

$$K = \frac{2\,u\,Q_b\,p_b L}{A\,(p_1^2 - p_2^2)}$$

Where Q_b is the volume rate of flow measured at atmospheric pressure p_b, in ml. per sec. The permeability coefficient, K, is an attribute of the porous medium, and theoretically, under certain conditions, is independent of the fluid used in its measurement.

In routine laboratory determinations of permeability, a selected core sample is cut or trimmed to cylindrical or rectangular cross-section, A, and of such length, L, as may fairly be representative of the rock stratum that the sample represents. This is sealed in or fitted into a supporting metal or rubber core holder in such fashion that when the core and its supporting element is mounted in its place in the permeameter, the flow medium (air, water, or oil) may be forced to flow through the specimen under controlled pressure-differential, without leakage of the flow medium around the specimen. Uniform temperature conditions are maintained. The quantity of fluid passing through the specimen per unit of time thus becomes a measure of its permeability. A porous medium has a permeability of one darcy when the rate of flow through it, measured in ml. per sec. per sq. cm. of cross-sectional area of a fluid



(After L. J. Klinkenberg)

Fig. 4. Illustrating method of determining permeability index by extrapolating plot of apparent permeability vs. reciprocal mean pressure to infinite pressure

of one centipoise viscosity under a pressure or equivalent hydraulic gradient of one atmosphere (76 cm. of mercury) per cm., is unity. It is a further requirement that viscous flow conditions must obtain. The darcy is too large a unit for convenient comparison of relative permeabilities, and it has become customary to express rock permeabilities in millidarcys.

Permeameters. An apparatus used in measuring permeability is called a "permeameter." Several different types of permeameters are used in laboratory measurement of rock permeabilities but suitable equipment for this purpose must possess certain essential elements. There must be provided a closed system of tanks, pipes, valves, and fittings from and through which the test fluid may flow under controlled pressure through the specimen to a receiving graduate or meter where its rate of flow may be measured. The test specimen must be supported in this flow circuit in such fashion that all fluid measured in the receiving graduate must pass through the specimen without leakage around it. Pressure gauges or manometers must be provided to indicate accurately the pressure at the up-stream and down-stream faces of the test specimen, and some means of controlling and regulating the up-stream pressure of the test fluid is essential. A graduated cylinder or burette receives the fluid as it flows from the specimen if a liquid is used; or if a gas is employed, a meter of appropriate type and sensitivity will be needed to measure its rate of flow. A stopwatch enables the operator to determine the volume of fluid passing through the test specimen per unit of time. Thermostatic temperature control of the apparatus and the test fluid are essential for accurate work, and a thermometer is provided to indicate the operating temperature. Other supplementary aids include a barometer for observing atmospheric pressure and measuring devices for accurately determining the size of the specimen. If a liquid is used as the test fluid, it should be filtered to remove suspended solids before passage through the specimen. Dissolved gas that may be present in a liquid under pressure should be avoided, otherwise gas released from solution in bubble form, may accumulate in the test specimen and influence the indicated permeability.

Commercial types of permeameters embodying these essential features are now available, but in many oil company test laboratories, specially designed and constructed permeameters are employed.

Mounting the test specimen. Among the problems involved in the operation of all permeameters, is that of mounting the test specimen in the supporting element so that leakage of the test fluid may not occur around the specimen. Two methods of preventing this are commonly employed. One involves use of a suitable wax or cement that may be placed around the specimen while in fluid condition, soon to harden and completely fill the annular space between the specimen and the supporting element. The alternate method involves support of the specimen in a snug-fitting stopper of soft rubber, or surrounding it by a sheath of rubber that is caused to press tightly against the outer surface of the specimen by exterior pressure. When an oil is used as the test medium, a variety of synthetic rubber resistant to oil decay should be used. When a cement or wax is employed, care should be taken in its application that it does not penetrate the pore spaces of the specimen or overflow the rock faces exposed to fluid flow.

Choice of the flow medium. As previously indicated, the test fluid may be either a liquid or a gas. Air, water, and oil have been widely used for this purpose, but the trend has lately been toward use of instruments that employ air. Water is objectionable inasmuch as it may result in hydration of clay and shale that may be present in the test specimen, causing swelling and reduction of pore space and permeability. From some points of view, oil should be preferable to air as a test medium, but a permeameter designed for use of oil is more costly, is less rapid in use, and problems incidental to determining viscosity of the medium and avoiding clogging tendencies from presence of fine suspended solids and gas bubbles are troublesome. It would appear that the almost stationary film of oil that adheres to the mineral grain surfaces would reduce to some extent the apparent permeability of the specimen when oil is used as the flow medium; and inasmuch as this is the condition that obtains in oil reservoirs, some au-

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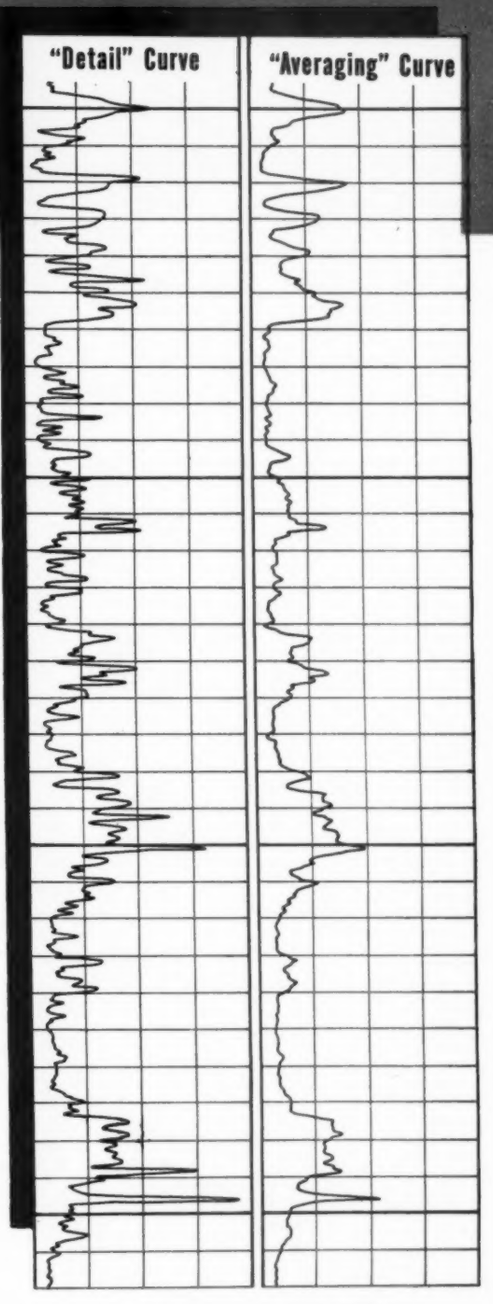

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thorities prefer oil to air. Apparently, however, the difference is slight and the greater convenience and rapidity possible with the air permeameter commend it to most analysts.

Laboratory procedure in making permeability tests. The size and form of the test specimen prepared for determination of permeability will depend upon the requirements imposed by the permeameter to be used, and more particularly by the form and size of the core holder. After the permeameter is designed to receive test specimens of cylindrical form, in which case they may be 1 cm. or more in length and will have a cross-sectional area of 2 to 10 sq. cm. Specimens will be carefully cut from representative portions of the larger core samples, preferably with the aid of a small diamond core drill, and may be cut at right angles to or parallel with the bedding planes as the purpose of the test may require. Perhaps a separate test specimen will be cut in each direction; or a specimen may be cut in cubical form so that it can be tested first with flow of fluid along bedding planes and later with flow across bedding planes.

After dressing the test samples to proper size and form, they are subjected to extraction in a Soxhlet extraction apparatus and thoroughly dried to remove all liquids from the interstitial pore space. The dimensions of the specimen are carefully measured and it is then mounted and sealed in the supporting element and inserted in operating position in the permeameter. If maximum accuracy is required, flow tests are made at several different pressure differentials and for each test the rate of flow and the pressures at the upstream and down-stream faces of the test-specimen are observed and recorded.

Computation of permeability. The value of the permeability index, K, is computed for each rate of flow with the aid of one or the other of the formulae, given in a foregoing section; and values of K are then plotted against the reciprocals of the mean pressures. If a gas permeameter is used, variation in the values of K will be noted, K varying as a linear function of the reciprocal of the mean pressure at which the test is conducted as long as conditions are within the range of viscous flow. Also, the resulting values of K will vary with the nature of the gas used. The preferred value for K is found by extrapolating the permeability graph to infinite pressure (i.e., reciprocal of mean pressure = o). (See Fig. 4.) So determined, the permeability obtained by using gas as the flow medium is equivalent to that computed from measurements made with a liquid as the flow medium. For approximate results, which are usually justified in view of the variation in lithologic properties of rock samples, one or two determinations of permeability at different flow rates will ordinarily be sufficient when using a liquid test medium. It is seldom that one may feel justified in reporting permeabilities in millidarcys with more than three significant figures.

American Petroleum Institute Code No. 27 offers the following examples of the method of applying the Darcy formula and computing permeabilities from observed permeameter measurements on a sample of Wilcox sandstone from a Mid-Continent field:

Dimensions of cylindrical sample:

Diameter = 1.905 cm.

Cross-sectional area = 2.85 sq. cm.

Length = 2.54 cm.

Test data:

With a liquid permeameter, using water as the flow medium;

Average rate of flow = 0.702 ml. per sec. per sq. cm. of cross-section.

Average pressure gradient = 1.1 atmospheres per cm. of length.

Viscosity of water at test temperature = 0.884 centipoises.

$$\text{Permeability, } K = \frac{(0.702)\,(0.884)}{1.11}$$

= 0.555 darcys = 555 millidarcys.

With a gas permeameter, using air as the flow medium:

Average rate of flow at mean pressure = 12.3 ml. per sec. per sq. cm. of cross-section.

Average pressure gradient = 0.400 atmospheres per cm. of length.

Viscosity of air at test temperature = 0.0182 centipoises.

$$\text{Permeability, } K = \frac{(12.3)\,(0.0182)}{0.400}$$

= 0.559 darcys = 559 millidarcys.

Another approach to the determination of the value of the permeability constant, K, when a gas is used as the flow medium, is provided by plotting the values of Q/A against corresponding values of $(p_2 - p_1)/L$. If flow is "viscous," this should result in a line of constant slope through the origin of coördinates. The slope of this line, expressed mathematically, is equal to K/u. If Q_b is the volume rate of flow, measured at base pressure p_b, values of $Q_b p_b/A$ are plotted against values of $(p_1^2 - p_2^2)/2L$ and again the result should be a straight line through the origin of coördinates, and the slope of this line is equal to K/u. In either case, if the flow is not viscous, the line will not be a straight line.

Thus, Figs. 5 and 6 present graphs expressing relationships existing between results of test data procured in permeability tests on a sample of Woodbine sand from a Gulf Coast field. In

Figs. 5 and 6. Graphs showing relationship existing between factors involved in measuring permeability of sandstone specimens

Fig. 5

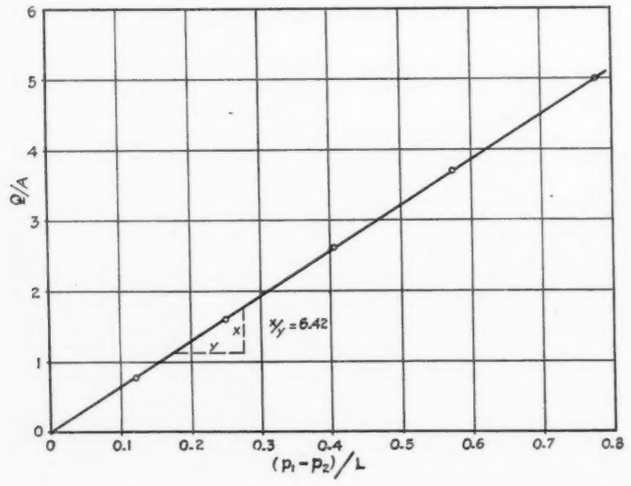
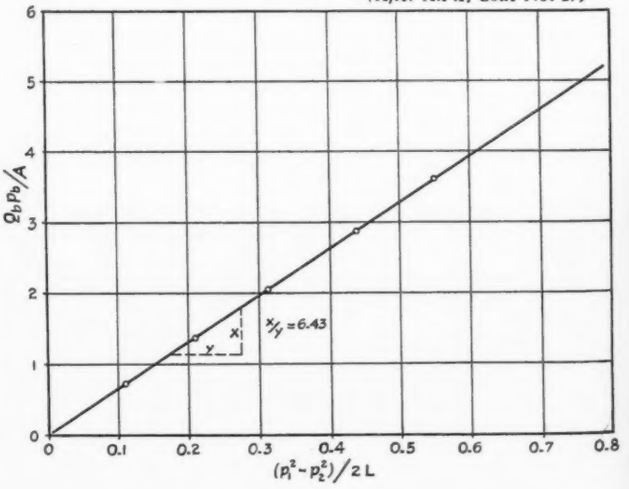
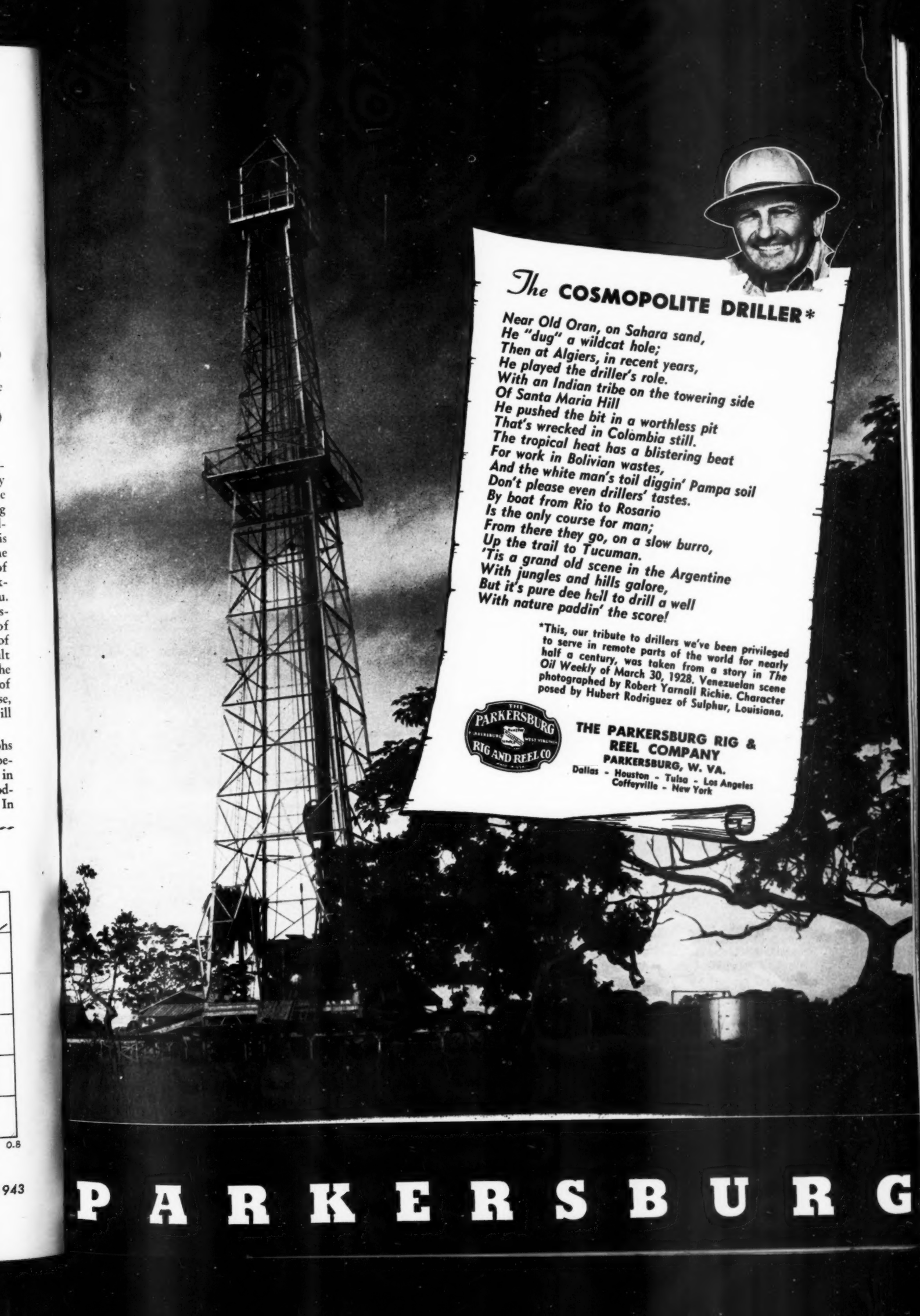


Fig. 6

(After A.P.I. Code No. 27)




The COSMOPOLITE DRILLER*
Near Old Oran, on Sahara sand,
He "dug" a wildcat hole;
Then at Algiers, in recent years,
He played the driller's role.
With an Indian tribe on the towering side
Of Santa Maria Hill
He pushed the bit in a worthless pit
That's wrecked in Colombia still.
The tropical heat has a blistering beat
For work in Bolivian wastes,
And the white man's toil diggin' Pampa soil
Don't please even drillers' tastes.
By boat from Rio to Rosario
Is the only course for man;
From there they go, on a slow burro,
Up the trail to Tucuman.
'Tis a grand old scene in the Argentine
With jungles and hills galore,
But it's pure dee hell to drill a well
With nature paddin' the score!
*This, our tribute to drillers we've been privileged to serve in remote parts of the world for nearly half a century, was taken from a story in The Oil Weekly of March 30, 1928. Venezuelan scene photographed by Robert Yarnall Richie. Character posed by Hubert Rodriguez of Sulphur, Louisiana.
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each case, the graph is a straight line of approximate slope 6.4 and if the viscosity of air is assumed to be 0.01827, the permeability, K, is computed at 117 millidarcys.

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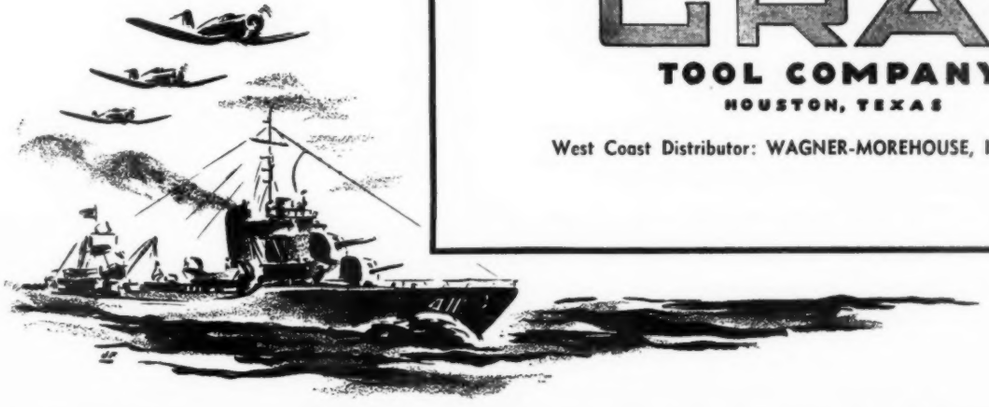

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THE various causes of corrosion have long been the subject of study by chemists, electrochemists, electrical engineers, and others. To those interested in the effect of corrosive action on pipe lines, not only the cause but also where and to what extent the corrosive action is taking place are of importance and interest. The effort necessary to determine the location of those areas where abnormal corrosive action is taking place varies according both to the extent and to which of the several kinds of corrosion processes is causing the abnormal attack. In some instances when it is known that certain of the corrosion processes are active it is a fairly simple matter to determine where and to what degree the pipe line is being affected by this action. As an example of this, consider the corrosion of a pipe line resulting from stray current electrolysis. The presence of stray currents in a pipe line can be readily detected and by the use of suitable instruments[1] and techniques[2], not only can the source and magnitude of the stray currents be determined, but it is also possible to ascertain where and to what extent the pipe line is being affected. It is possible to protect the pipe line against such corrosive action by applying natural cathodic protection although it is not always economically feasible to do so.

There are other types of corrosion processes that can be found as readily as stray currents, and numerous suitable methods for their detection have been described in various publications. There remain, however, several types of corrosion processes that are not so readily detected, although they may be causing severe damage to the pipe line over a distance of from a few inches to hundreds of feet and, if it is desired to combat successfully the corrosion problem by means of preventive maintenance, it becomes necessary to employ some method for detecting such areas that is reliable, yet relatively simple. Many such corrosion survey methods have been suggested, a few of which appear to have some value for the detection of some forms of corrosive action. Logan and Koenig[3] have made an excellent comparison of the better known methods. It has been found that, in practical use, neither any single method nor any combination of methods will produce results of sufficient value to make their use universally acceptable, because they fail to give any indication of the presence of certain types of corrosion, particularly microbiological anaërobic corrosion.

Because of the fact that it is so difficult to find many of the sections on a pipe line where excessive corrosive action is taking place many companies have resorted to applying protection against this action to the entire line. This is usually accomplished by the use of suitable coatings, cathodic protection, or a combination of both, the kind of protection depending on the extent as well as the nature of the corrosion attack. Protection of the entire line will accomplish its purpose, but is extravagant inasmuch as normally a relatively small percentage of any pipe line will require protection during its economic life. There are several pipe lines, which have been in use for decades, that are still employed for high-pressure service that are unprotected throughout the major part of their length. They do have "hot spots" where the pipe needs replacement at fairly frequent intervals if protection is not applied; however, the rest of the line is still in usable condition.

Prior to actual construction of our company's pipe line in the state of Ohio in 1931 a survey was made of the various soils along the proposed route. This survey indicated that there were very few locations where the soil was excessively corrosive, and soil resistivity measurements made shortly after the completion of the line gave the same indication. Experiences of other pipeline operators in the same general area, however, inclined us to the belief that perhaps the soil corrosion was more severe than had been implied. This belief led us, in 1937, to make visual inspections. In several locations inspected, where, according to both the soil survey and the soil resistance measurements, there should be no severe corrosive action it was found necessary to replace the pipe. In a short time enough evidence had been gathered to convince us that there must be several locations on our pipe line in need of protection. As it would be extravagant to protect the entire line, and the usual methods for determining soil corrosivity had proved unsatisfactory, it was decided the best solution would be to continue the visual examinations.

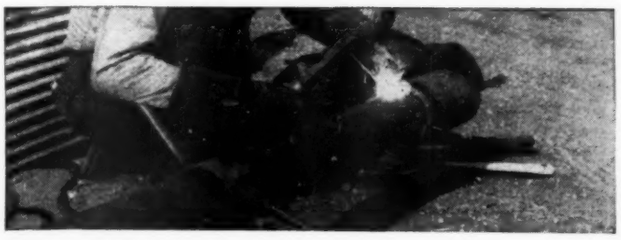
Visual Examination

The effectiveness of visual examination in determining the condition of a pipe line has long been discussed by corrosion investigators. For purposes of evaluation it has been customary to dig examination holes at certain intervals, but there has never been any agreement on what that interval should be. Since conditions along pipe lines vary, it is impossible to determine what the distance between the examination holes

THE AUTHOR

Donald F. Van de Water was born in New York State in 1909—Attended the United States Naval Academy and Rensselaer Polytechnic Institute—Entered the employ of the Electrolysis Department of the Susquehanna Pipe Line Company in 1934.

TOOL JOINTS REBUILT THIS WAY LAST TWICE AS LONG AS NEW ONES



1. Operator is shown here welding a worn tool joint to a pipe section. Since this weld will not be subject to friction and abrasive wear, an ordinary mild steel electrode is used.

2. Next, a copper form is butted up to the mild steel deposit and clamped into position. This holds into place a bead of Stoody Self-Hardening "K" which is then applied to the shoulder.

3. Often—in cases of excessive wear—two layers of Stoody Self-Hardening "K" must be deposited on the shoulder to restore the tool joint to normal size.

4. After the shoulder is rebuilt, the copper form is removed. Another circumferential bead of Stoodite is applied parallel to the shoulder bead. Together they act as guides for the horizontal welds.

New Self-Hardening
ELECTRODES AND RODS
Obtainable on Low Priority Ratings

A sure method of salvaging worn tool joints is by rebuilding with Stoody Self-Hardening "K", the new low priority welding rods and electrodes.

Stoody "K" deposits show hardnesses of 50-54 for oxyacetylene, 50-52 for arc applications. They are dense—free from weakening porosity. Field tests show that Stoody "K" offers excellent resistance to abrasive wear . . . will withstand considerable pressure and impact. Pamphlet on request.

5. Finally, horizontal beads are applied between the two circumferential deposits. These are built up sufficiently high to restore to proper size the outside diameter of the worn tool joint.

IDLE CYLINDERS ARE PRODUCTION SLACKERS: KEEP 'EM ROLLING FOR VICTORY.

should be, if it is desired to ascertain where the abnormal corrosion is taking place. It was decided, therefore, not to make the inspections at any predetermined distance from each other, but rather to investigate not only all those locations where abnormal corrosion action is likely to be encountered, but also to examine the pipe where a leak would be particularly dangerous, even though excessive corrosion is unlikely. In examining the pipe line at all such locations several thousand examinations have been made. They were begun in the summer of 1937 and carried on continually except during the winter months until the summer of 1942 when the entire system had been inspected. The results obtained have been very successful.

The success of any method of preventive maintenance is usually judged by the development or non-development of leaks. Past leak records are often used as a basis for estimating the number of leaks that will occur in the future by plotting the "leak-time curve." If no protection is applied, the number of leaks per year will be subject to some exponential rate of increase as time goes on. If protection is effectively applied, however, it is difficult to obtain a true "leak-time curve," as it is impossible to determine how many potential leaks have been prevented by the application of protection. As more protection is applied the more difficult becomes the problem of obtaining the data necessary to foretell the number of future leaks.

Leaks Classified

All leaks that have occurred on our line since construction have been divided into three classifications. First, the leaks that occurred prior to inspection, second, those that have occurred since inspection, and third, those that have occurred in locations that, although inspected and found in need of protection, had not been protected due to the inability of the maintenance divisions to keep pace with the inspection parties.

Those leaks occurring prior to inspection averaged one leak per year per 410 miles of pipe. The first leaks were caused by the combined action of acid waters from coal mines and stray current electrolysis, in one instance a 2-in. steel pipe of standard wall thickness being perforated in less than one year. Other leaks were caused by the action of acid waters alone and still others by carbon contact.

Leaks after inspection had been made have occurred at an average of one leak per year per 800 miles of pipe. These leaks have resulted from the action of various forms of corrosion processes, some of which are very uncommon and will seldom be encountered. One leak was found in a location where, according to our previous experiences, the pipe should have been in good condition. In fact, except for a few feet on either side of the leak there was no indication of any serious corrosion on the pipe line. Upon investigation it was found that for several years prior to the general use of electrical refrigerators the proprietor of a nearby country store had dumped the waste brine from his

Figs. 1 and 2 show the type of inspection cards used to record data by inspection parties

Fig. 1

COUNTY_____ MAXIMUM PIT_____ DATE_____

STATION NUMBER_____ STATE_____ LINE_____

PROPERTY OWNER_____ PROPERTY NUMBER_____

THIS IS_____ EXAMINATION

FEET OF PIPE EXAMINED_____ ON_____ SIDE

TEST HOLE LOCATED IN_____

TEST HOLE_____ FULL OF WATER

TYPE OF SOIL:_____

PRODUCTS OF CORROSION ON PIPE_____

TYPE OF ATTACK_____

_____ METAL SHOWING IN_____

GENERAL CONDITION OF PIPE_____

Form SUS-121-A 10M 10-40 Printed in U. S. A.

Fig. 2

PITS MEASURED_____

RECOMMENDATIONS_____

NUMBER OF FEET OF BOXING REQUIRED_____

pH OF WATER_____, $\frac{H_2O}{10}$ = _____ $\frac{H_2O}{20}$ = _____ $\frac{H_2O}{50}$ = _____ $\frac{H_2O}{100}$ = _____, pH OF DISTILLED H_2O = _____

REMARKS:_____

ESTIMATED DAMAGES_____ DAMAGES PAID_____

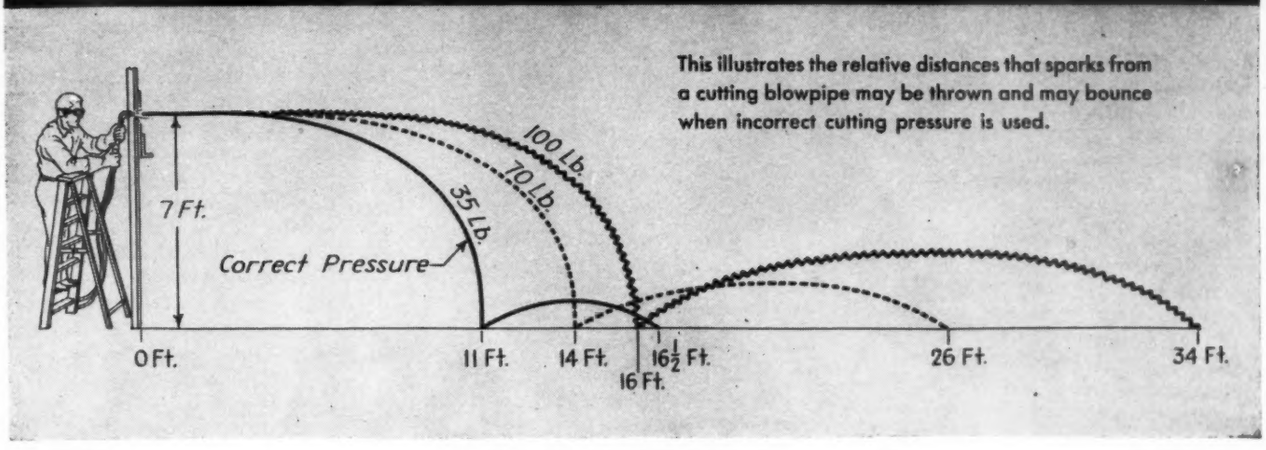
COMPLETED WORK

_____ FEET OF BOXING INSTALLED_____

NAME OF MAN MAKING THIS INSPECTION_____

CARD CHECKED AND ADDED TO REEXAMINATION SCHEDULE BY_____

WATCH THOSE *Sparks*..
TO MINIMIZE FIRE HAZARD



During oxy-acetylene cutting operations, the larger the area into which sparks are thrown, the greater will be the danger of fire. Sparks scattered several feet from the scene of cutting may lodge in cracks or crevices of combustible material and smoulder there unnoticed until flames burst forth. Sparks should, therefore, be confined to as small an area as possible.

Avoid Excessive Pressures

A most important factor in controlling sparks is the use of no more than the correct oxygen pressure as specified in the instructions supplied with each blowpipe. Excessive oxygen pressure not only wastes oxygen, produces an inferior quality of cut, and slows cutting by the cooling effect of the excess oxygen, but also increases the distance that hot slag or sparks are thrown—particularly when the cutting is done in a horizontal position.

Use a Spark Shield!

An effective shield, which will reduce the distance that sparks are thrown, can be improvised by suspending sheet metal or asbestos paper 2 or 3 feet square, in the path of the sparks about 18 inches from the blowpipe. Such a shield will prevent sparks from flying or rolling great distances and will thereby lessen the danger of fire.

Instruction Books Available

The instruction books packed with all oxy-acetylene blowpipes supplied by Linde include charts showing correct gas pressures to be used. Duplicate copies will be sent, without charge, upon request. Be sure to specify the blowpipes you have.

Also available from any Linde office is the booklet "Preventing Welding and Cutting Fires."

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☐ Prest-O-Weld Type.....

2. The booklet "Preventing Welding and Cutting Fires."

Name .....
Street and Number .....
City and State .....

The words "Linde," "Prest-O-Lite," "Union," "Oxweld," "Purox," and "Prest-O-Weld" are trade-marks.

salt and ice refrigerator in this particular spot. At the location of another leak the carbon electrodes from two ignition batteries were found against the pipe line, the batteries apparently having been thrown in with the backfill at the time of constructing the line. In practically all cases where leaks were discovered after inspection, it was found that the corrosive factors that caused the leak had affected only a few feet of the pipe line. It is quite improbable that any method of detecting excessive corrosive action would have detected these locations except by accident.

Inasmuch as the number of leaks since inspection has been far less than the number indicated by the "time-leak curve," it seems reasonable to assume that the protection applied has been effective. As many of the locations requiring protection could not possibly have been detected by any method other than visual examination, our present system of protective maintenance has proved itself most satisfactory and is worthy of consideration by anyone interested in reducing the effects of corrosion processes to a minimum.

Inspection Must Be Systematic

Preventive maintenance by visual inspection to be successful must be systematic. During the six years we have been using the system a definite plan has been followed in all phases of the work.

Trained examiners make the inspections at all locations where experience has shown that corrosion processes are apt to be abnormally active and at those locations where the results of excessive corrosion would be dangerous, even though such corrosion is not likely to be found. Those locations where excessive corrosive activity is likely to occur include low spots, swamps, and bogs, for these locations are apt to be undergoing microbiological anaërobic corrosion. Other locations where examinations are made include railroad crossings, highway crossings, cinder fills, coal bloom outcrops, stream crossings, mine water runs, etc. It is true that by examining the pipe at all such locations many inspections of the pipe will be made in areas where only minor corrosion is occurring; however, knowing where serious corrosive action is not taking place is nearly of as much value as knowing where the corrosion attack is abnormal.

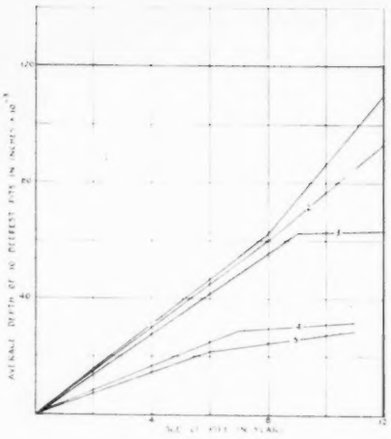

Fig. 4. Curves plotted from data obtained from re-examinations

After the examiner has selected the location to be inspected an inspection hole is dug, exposing from 7 to 10 ft. of pipe. It has been found this amount of pipe will usually be sufficient for a reliable examination.

After the pipe line has been exposed a complete examination is made and various data, which consist of the following items, are recorded:

1. A detailed description of the location. This includes an identifying description so that, if necessary, the location can be found again at some later date; a description of the terrain, that is, a swamp, low spot, cinder fill, etc., the amount of water in the test hole, the amount of pipe actually examined and the proximity of any railroads, highways, streams or buildings.

Fig. 3

REEXAMINATION SCHEDULE

County	Station No.	Line	Previous Examination Date	Maximum Pit

Form SUS-121-B 2M 7-41 Printed in U. S. A.

2. A description of the soil. This includes color, approximate water content, size of soil particles, and the presence of foreign substances such as cinders, coal, decayed vegetation, etc.

3. A description of the corrosion products including their color, thickness, and hardness. The iron salts usually found are ferric oxide, ferrous oxide, ferrous sulphide, ferrous carbonate, ferrous hydroxide, and occasionally the magnetic ferro-ferric oxide. As ferrous salts are quite unstable and readily susceptible to oxidation, it is imperative they be examined as soon as possible after the pipe is uncovered. These various iron salts are all quite readily recognized, although there is some difficulty in differentiating between ferrous sulphide and ferrous oxide as well as between ferrous sulphide and ferrous carbonate. A simple qualitative field test is made that aids in the identification of these salts. A few drops of dilute hydrochloric acid are added to a small sample of the unidentified salt. Ferrous oxide produces no reaction, whereas ferrous carbonate produces a rapid reaction with the generation of carbon dioxide. If the salt is ferrous sulphide the reaction will be slow and foamy with the generation of hydrogen sulphide gas, which is readily identified by its odor. As microbiological anaërobic corrosion attack has been proved to be quite severe, this test with hydrochloric acid is made at every examination to detect the presence or absence of ferrous sulphide, which is an indication of the microbiological anaërobic corrosion.

If an abundance of ferric oxide is found, it is usually not considered necessary to make a further examination, as normally it is an indication that active corrosion has ceased or is tapering off to some degree. The coat of ferric oxide, therefore, is not, ordinarily, disturbed.

4. A description of the type of attack. This includes the size, shape, and relative number of the corroded areas, be they pits or large areas. The appearance of the corroded areas is also described; that is, whether the metal is bright, dull, or rusty, for this is an indication of the activity of the corrosion. The general condition of the pipe is also included.

5. The depths of a representative number of pits and slabs are measured. At least 10 and usually 15 is the average number required. These depths are measured with a micrometer depth gauge that has been adapted to this particular use. Where there are corroded areas or slabs too large to be measured with the regular depth gauge a special "slab-measuring bar" is used.

6. After a complete examination the examiner makes his recommendations

4 SIMPLE RULES OF PUMP CONSERVATION

1. KEEP PUMPS CLEAN

2. CHANGE CRANKCASE LUBRICANT AT LEAST TWICE A YEAR

3. ADJUST BEARINGS AT FIRST SIGN OF LOOSENESS

4. DO NOT OVERLOAD THE PUMP

We have portrayed the rules of pump conservation humorously, but they have a mighty serious meaning in these war days.

Upon the care that you give your pumps depends your ability to get out of them ALL of the dependable service that we have built into them. This is important not only from your own standpoint, but from the standpoint of the nation. For pumps represent metals, manpower and transportation which we can't afford to waste.

May we suggest that patriotism and self-interest both call for the establishment of a special wartime program of pump conservation, based on the rigid fulfillment of the rules above outlined? ... Gaso Pump & Burner Mfg. Co., 902 E. First Street, Tulsa, Oklahoma. Export Office: 149 Broadway, New York. Los Angeles: Service Oil Field Supply Co., 5333 S. Riverside Drive.

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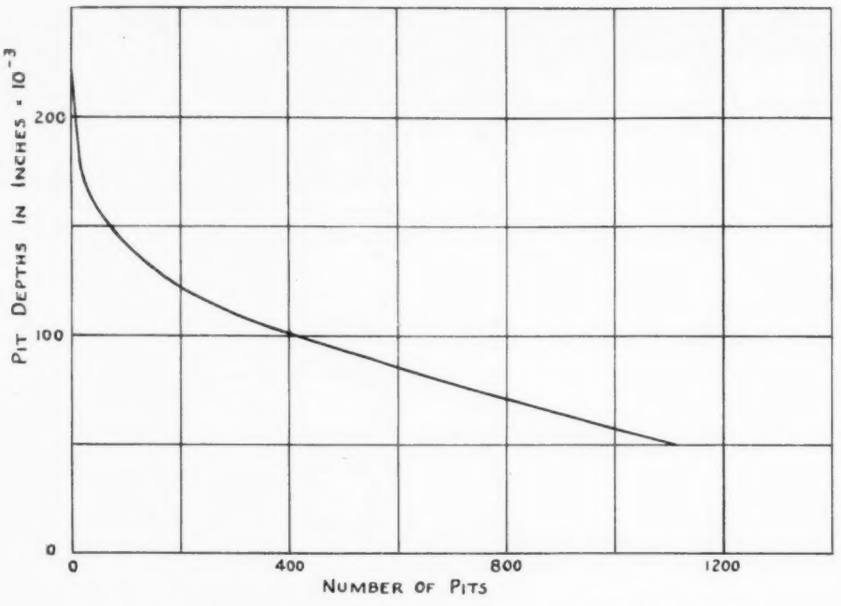

Fig. 5. Cumulative pit depth frequency curve for 500 ft. of 6-in. uncoated steel pipe nine years old

regarding what treatment is needed at the particular location. If he decides that the pipe is in safe condition and further corrosive attack will not be extensive he states that no further examination need be made. If he finds that the pipe is severely corroded and in need of protection, however, he estimates how much pipe will require protection in the particular location and how soon it should be protected. If the pipe is found to be not in particular need of protection, yet the corrosion processes are still active, the examiner recommends a re-examination at a later date. This re-examination may occur after a period of years when it will be possible to tell whether the corrosive action has progressed, and if so, to what extent. Because few examined locations are exactly alike it is impossible to lay down any set rules for determining when the re-examination should take place.

7. If water is present in the examination hole its pH is measured to determine whether conditions are such that microbiological anaërobic corrosion attack might be taking place. It has been found that normally for this type of corrosion process to be particularly severe two requirements have to be satisfied. The first requirement is that the soil must be airtight or water-saturated so that no oxygen is available at pipe depth; secondly, the pH of the soil water must be about 7.0, with variations of + 0.8 the limits within which severe corrosive attack will take place. Fulfillment of both conditions is an indication that microbiological anaërobic corrosion may or may not exist. Lack of either requirement is an indication that microbiological anaërobic corrosion attack is extremely unlikely to be encountered.

The pH measurements are made colorimetrically with a block comparator. Determinations of pH in this manner, although not precise, are of sufficient accuracy to be used. The pH of soil waters has normally been found to be between 6.0 and 7.4, although in the coal mining areas higher acid conditions are sometimes found, but only rarely are values of less than 4.5 pH encountered.

8. Any other data the examiner considers pertinent and of aid in determining the cause of corrosion or non-corrosion at the particular location.

Recording Data

Figs. 1 and 2 show the inspection cards used for recording the data by inspection parties.

After completion of the examination the data are sent to the Electrolysis Department, this department being responsible for the corrosion mitigation program of the company. The data are reviewed for each location to determine whether the examiner has made the correct recommendations regarding protection or re-examination. After any corrections that may be necessary, copies are made and sent to the superintendent of the division in which the examination was made. The superintendent is then able to formulate his program for applying the necessary kind of protection specified by the Electrolysis Department. After the necessary protection has been applied the Electrolysis Department is informed of the locations, amount of protection, and the date of its completion. This information is entered on the original cards, which are retained by the Electrolysis Department. In this way the progress of the protection program in all divisions can be closely followed.

When a re-examination is recommended for a location the pertinent data are added to the re-examination schedule. Fig. 3 shows the form used for this schedule, which is filed chronologically, making it possible to determine where re-examinations are to be made in any one year without having to review all the inspection cards.

After these re-examinations a comparison is made between the data obtained at the time of the first examination and the data from the subsequent re-examination. From these data it is possible to ascertain the rate of progress of the corrosive action. Recently several re-examinations were made at various locations. Fig. 4 illustrates a few typical curves obtained from these re-examinations. In some cases the rate of corrosion had increased as shown in curve 1; curve 2 is typical of several locations where the rate was practically linear; and curves 3, 4, and 5 show the results of the tapering off of the corrosive activity at different locations.

Corrosion Not Accelerated

One criticism frequently made regarding visual inspection is that in digging the examination hole the earth around the pipe is disturbed, causing the corrosion process to proceed at an accelerated rate. Actually, as pointed out previously, when ferric oxide is present, indicating the free access of oxygen to the pipe, the ferric oxide is not removed, so that further aeration causes little additional corrosion attack. It has also been found that when the pipe is in a reduced environment it soon returns to that state even though the soil that was removed to make the examination has become aerated before being replaced. Measurements have been made with the Pearson earth current meter at such locations, prior to opening the test hole and then repeating the measurements a few days after the examination hole had been backfilled, and it was found that there was little or no difference in the electrical currents discharged by the pipe. In view of these facts, then, it does not seem that ordinarily the corrosion processes are disturbed to any great extent by digging examination holes.

It is true that in some cases an accelerated rate of corrosion attack has been found, but at all these locations there was strong evidence of micro-

Help prevent another dark age from settling down on the spirit of man!

Consider the cost if we lose this war. For the immediate future there would be slavery, hunger, degradation, as is already the lot of other nations which only wanted peace and to be let alone each to work out its separate destiny. For years to come we would be struggling to regain freedom of worship, freedom to explore unhampered science and art, freedom to be individuals again.

Your buying War Savings Bonds to the very limit of your ability will help clothe, feed and arm our boys and transport them to the front lines so that they may roll back the scourge of civilization—the present day Jenghis Khan.

In addition to insuring liberty and the good things which our way of life has made possible far beyond the fondest dreams of other peoples, your buying War Savings Bonds regularly will give you the cash after the war to buy the wonderful new cars, television sets, labor-saving appliances for the home, and the many miracles of the new age of plastics and chemurgy. An immense purchasing reservoir of money built up by millions of bond buyers will help insure continued prosperity and employment after victory.

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biological anaërobic corrosion, whereas at those locations where the rate was lineal, or had decreased, there was little or no indication of such an attack. It, therefore, appears that the kind of corrosive environment rather than the aeration of the soil is responsible for the rate of corrosion.

Of all the examinations made since the beginning of the visual examination system approximately 16 percent have required protection. This is a relatively low percentage due primarily to two reasons. Many examinations were made at road crossings, railroad crossings, and other locations where it was deemed advisable, as a matter of public safety, to know the conditions of the pipe line, although previous experience had indicated these locations were not always potential "hot spots." If only the potential "hot spots" were examined the total number of examinations would be lessened thereby increasing the percentage of examined locations requiring protection.

The second reason for the low percentage is that when a long swamp, bog, or low spot is examined the first inspection hole is dug in that part where the examiner believes the corrosion attack to be most severe. If, as is the case the greater part of the time, this first examination reveals that protection is required, no further examinations are made in that particular swamp, bog, or low spot. It is assumed that protection is required for the entire section and the actual extent will be determined by the maintenance crew at the time of installing the protection. This method contributes to the low percentage of examinations requiring protection due to the fact that one examination may suffice to show required protection for several hundred feet or more. If the first examination does not reveal that protection is required, however, it is necessary to continue the examinations until a sufficient number have been made to indicate that the pipe does require protection, or to satisfy the examiner that he has given the location a thorough examination.

Thus far protection has been applied to less than 10 percent of the line. There is still some protection to be applied in the near future and it is not unlikely that further re-examinations will disclose need of even more, but it is doubtful whether more than 15 percent of the line will require protection during its estimated economic life.

The amount of protection applied to different locations has varied; in some locations it has been found necessary to protect no more than 20 or 30 ft. of pipe whereas in other locations hundreds of feet of pipe are now protected against further corrosive action.

Cost of Examination

The cost of making an examination can readily be determined. One laborer can, under normal conditions, dig and backfill one examination hole per 8-hour day. The examiner can usually make 9 or 10 examinations during the same time. Including transportation and incidental costs it has been found that the average examination has cost about $10. This means that for the entire pipe line the cost per mile has been approximately $65. This cost plus the cost of applying such protection as has been needed is considerably less than would have been the cost of protecting the entire line. Future re-examinations will add to the cost, but the per annum expense will be relatively low.

Another saving is in the number of leaks and reconditioning labor averted by applying the required protection indicated by the visual examinations. These data are, however, difficult to obtain, although they have been determined for one particular location that was in a typical swampy pasture several hundred feet long. An inspection hole was dug where previous experience indicated excessive corrosive action might be found and the pipe was found to be undergoing severe microbiological anaërobic corrosion indicating that protection was necessary. When the line was uncovered for the application of protection the depths of all the corroded areas and pits on about 500 ft. of the line were measured. Fig. 5 shows the results of these measurements. Of all the depths measured several were found that could be classed as potential leaks within from one to five years, due to the accelerated rate of the microbiological anaërobic corrosion process. If this location had been left unprotected until the development of the first leak it is certain that extensive reconditioning or replacement of the pipe would have been necessary.

It must be realized that conditions at the abovementioned location are not extreme, but are typical of many hundred such places that have been found while making visual examinations. Although no data have been kept regarding the actual number of potential leaks prevented at those locations where protection has been applied, it is certain that the number is at least in the thousands. Many of the locations where potential leaks were found are in densely populated and urban sections where an actual leak could cause inestimable damage.

Not only have thousands of such leaks already been prevented, but by means of the re-examinations it will be possible to prevent many more. No one can estimate what the actual savings have been, but it is certain that preventive maintenance by systematic pipe-line inspection is an inexpensive form of insurance.

Information and data obtained in making the visual examinations have been largely responsible for the investigations and research by R. F. Hadley,[4, 5, 6, 7] concerning the microbiological anaërobic corrosion process. These investigations and research have not only contributed much to the understanding of this heretofore neglected phase of corrosion investigation, but have pointed the way to the use of oxidation reduction potentials for determining the existence and intensity of microbiological anaërobic corrosion.[8] When this method has been developed for use in the field it will be of great value to all corrosion investigators. Although this result alone is of importance, it is only incidental to the practical results that have been obtained, for by making these visual examinations systematically it has been possible for us to maintain our entire pipe-line system in a far safer condition than would otherwise have been possible had any of the other corrosion survey methods been used.

The writer wishes to express his appreciation to R. F. Hadley of the Susquehanna Pipe Line Company for his many valuable suggestions relative to the preparation of this article.

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Maintenance of Pumping Station Equipment

PETROLEUM ENGINEER Exclusive Feature

PART 3 (Concluded)

by E. R. Spencer

Engineering Department, The Cooper-Bessemer Corporation

MUCH time can be spent in discussing bearing and rod alignments because a different method of checking is applicable to each of many types of equipment. The methods described in this article are largely applied to heavy-duty, slow-speed, vertical engines that are found in many pipe-line pumping stations.

Much trouble can be encountered in machinery if the piston does not align with its adjacent parts; namely, the piston pin bore, rods, and the bearings, etc. In Fig. 4 is shown one way of checking the alignment of piston and rod with the connecting rod in place. The piston is set on its head and leveled, then the rod is placed in its exact vertical position and, by means of a straight edge alongside the piston skirt perpendicular to the rod movement, the distance "X" and "YW" are noted. These two dimensions must be equal provided the end clearance in the piston pin bearing is divided equally. To determine the exact location of the straight edge, so as to measure "X" and "Y" perpendicular to the rod movement, scribe a line on the piston skirt with a try square vertically through the center of the piston pin on both sides of the piston. A straight edge directly over these lines will locate it in the center of the piston and 90° with the rod movement. This method will also give a check on the piston pin bore or a possible tapered pin, provided that the pin bearing has been checked for a true bore. A tapered pin is usually found by measuring with micrometers, however.

Another procedure of checking the piston bore through the piston is shown in Fig. 5. The piston, with pin in place, is leveled on its head by a level and a combination tool or by a straight edge and a level across the end of the piston skirt. (Wedges under the piston head will simplify leveling the piston.) A level "L" on the pin will reveal any variation in pin alignment relative to the piston, which may be attributed to an untrue pin bore. Fig. 6 shows how a piston can be leveled by suspending heavy weights or plumb bobs by fine wire from a rod placed across the end of the skirt parallel then perpendicular to the axis of the pin. Wedges are moved under the piston until dimensions "W" and "X," which are measured by micrometers or a pin gauge, are equal. Dimensions "Y" and "Z" then should also be equal and represent a check of the other readings. The level "L" should show the pin as being perfectly level if no defects are found.

The weights or plum bobs have a tendency to swing when subject to wind or even slight handling. This can be overcome to a great extent by submerging them in a heavy liquid such as heavy lubricating oil or its equivalent.

Nothing has yet been said about the cylinder, which plays an important part in all engines. Liners are replaced more often than bearings and many of the other parts. Therefore, the chances of having a liner misaligned are more numerous, due to improper installation or poor construction. Some maintenance men seldom check a replaced liner to see whether it is perpendicular to the crankshaft. A check of this nature is worth while because excessive liner wear with the possibility of sticking a piston caused by misalignment is expensive.

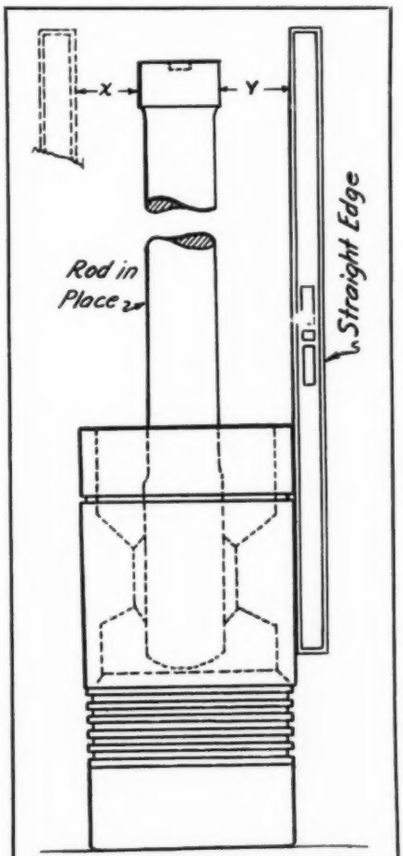


Fig. 4. A method of checking alignment of piston and rod with connecting rod in place

One method in checking a replaced liner is to place a straight edge and a level across the top of the liner. Another method is shown in Fig. 7. The rod or stick from which weights or plum bobs are suspended by fine wire is placed across the top of the liner parallel to the shaft. The weights are suspended through the liner into the crankcase and about 2 or 3 in. from the liner wall. The distance "O" and "P" should be equal and, as a check, "M" and "N" should also be equal. The rod is now placed perpendicular to the shaft and the procedure repeated. This method, if accurately performed, will give a very definite indication regarding the alignment of the liner.

The subject of alignment deals not only with the items discussed but with practically all moving parts throughout an engine. Only the more complicated procedures were brought out in this article because of the lack of time and space required to discuss in detail all necessary alignments.

Although some maintenance men give little attention to the matter of bearing clearances, it is one of the most important factors in operating pumping equipment. It is good practice to allow standardized bearing clearances that are applicable to that particular type of engine and pump. These clearances have been standardized by actual tests. It is just as detrimental to have too much clearance as not enough because the bearing will pound out. When setting bearings, one should be careful and allow only what is considered a standard tolerance or a clearance that has already proved satisfactory.

There are several ways of checking bearings for clearances. One simple method is the using of a thickness gauge, when possible, such as on pump pinion and main shaft bearings. Another method is "leading" bearings. This procedure is simple but takes more time and has been found a satisfactory one. In "leading" main bearings, the caps are removed and a lead or fuse wire is laid over the journal at each end of the bearing; the ends of the lead wire are

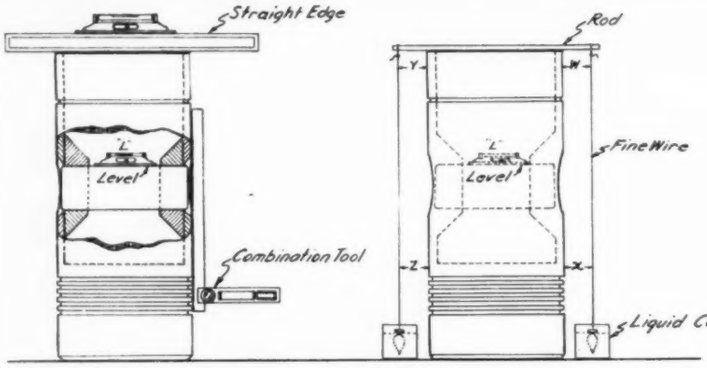


Fig. 5. Another method of checking piston bore through piston

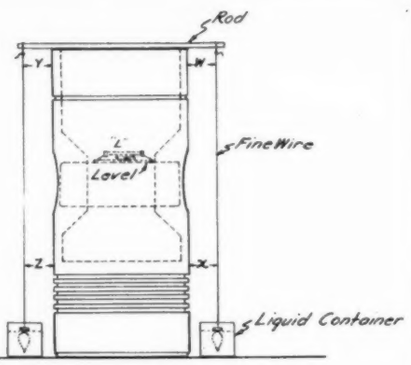


Fig. 6. Method of leveling a piston

to be approximately 1 in. from the shims. The cap is then replaced and tightened after which it is again removed and the lead wire "miked" for thickness. The measurement of the thickness indicates the clearance. In checking crank bearing clearances, the crank pin is placed near the top dead center position and the bearing is lowered enough to insert lead wire in bottom of cap, one at each end. The cap is then tightened to the rod with proper tension on the bolts, after which the cap is again lowered and the lead wire removed and measured for thickness. The clearance of this bearing is indicated by the thickness of this lead wire.

The size of lead wire used depends largely upon the size of the bearing and the required tolerance. A 2-amp. fuse wire is very satisfactory for "leading" bearing on pumping equipment.

Another method of checking crank pin bearing clearance is shown in Fig. 8. The dial indicator is clamped to the connecting rod with the dial pin resting on the crank web. After setting the dial and noting the initial reading, by means of a long rod or timer the connecting rod and bearing are forced up to the crank pin. The dial reading is again observed and the difference between this reading and the initial reading is the bearing clearance.

The crankshaft is one of the most important and costly items in engine and pump design. As its construction is complicated and replacement of such a shaft in pumping equipment would mean a long shutdown period, it must be given great care. Failure of crankshafts is largely attributed to improper alignment, due to high and low bearings, which cause the shaft to "bow." A check for flexure, fractures, and alignment should be periodical.

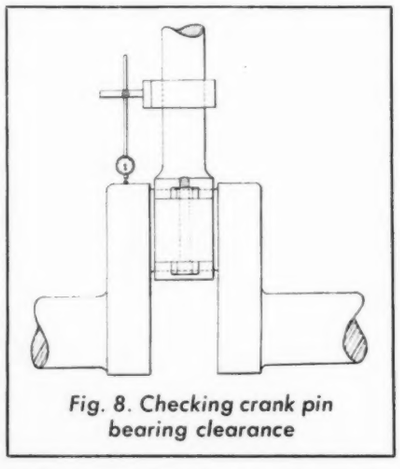
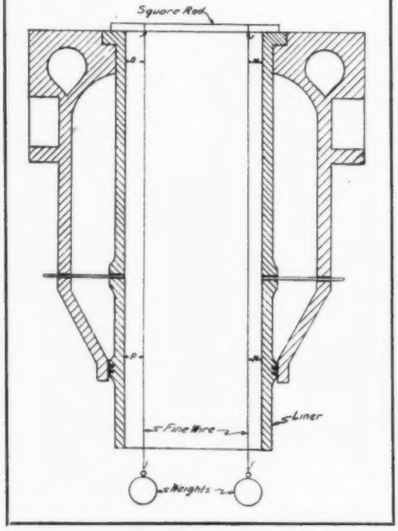


Fig. 8. Checking crank pin bearing clearance

Fig. 7. Checking a replaced liner

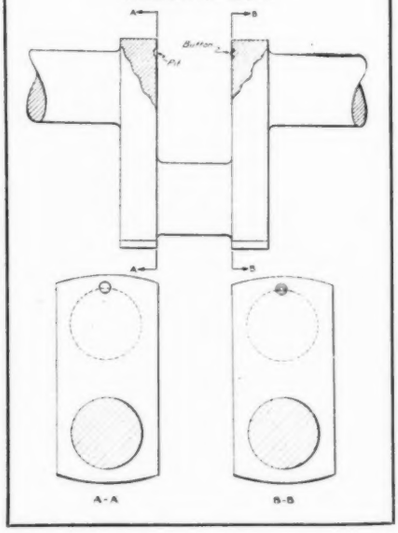


Fractures are generally found in the fillet of the journals near the crank web due to concentration of stresses at these places. They are very seldom visible to the naked eye in the early stages, therefore, some procedure must be followed in detecting these possible fractures before the shaft is completely broken. The following is one of several methods: clean the shaft until it is free of all greases and oils, then after drying thoroughly, apply a thin coat of a mixture of alcohol and powdered chalk with a brush around the journals at the fillet. The alcohol will evaporate readily, leaving the surface covered with a thin coat of chalk. As the shaft is rotated, any fracture that may be present will be indicated by streaks of oil working out of the crack and appearing in the white chalk showing the extent of the fracture. For best results of the procedure, the shaft, when rotated, should be suspended by only the two end bearings.

The shaft must be straight and supported equally by all bearings, otherwise it will "bow" and fractures may occur. In checking a shaft for flexure or bow, the crank webs should be prepared to receive micrometer calipers or a strain gauge. The webs should contain small center punch indentations to receive the points of a strain gauge. Where micrometers are to be used, the webs should have a pit on one side and a button on the other near the top and the center of the web, see Fig. 9. The pit is made by hammering on a small steel ball held against the web with an improvised clamp. The indentation made by the ball will receive the stem of the micrometers. Drilling to the depth of the taper of a small drill will also make suitable pits. The button that contacts the head of the calipers is made by a specially machined tool. See Fig. 10 (b) and (c). Another method of making the button is shown in Fig. 10 (a). A hole the size of a small steel ball is drilled into the web to a depth equal to ¾ of the ball diameter. The ball is inserted into this hole and the metal caulked around it to prevent its falling out. The pit and the button must be smooth and free from burrs and carbon deposits so that one can obtain correct micrometer readings between these two points.

The readings are taken at four positions of the crank pin; namely, top, back, bottom, and front, designated by A, B, C, and D, taken in the order of

Fig. 9. Checking a shaft for flexure or bow



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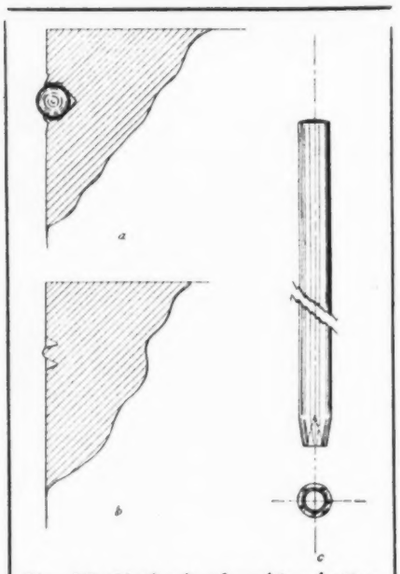


Fig. 10. Methods of making button on crank web for use of micrometer calipers

rotation of the engine. If the readings are equal in the four positions of the crank pin, the indications are that the shaft is straight. Variation in these readings will indicate a misaligned shaft due to bends or misaligned main bearings. In Fig. 11 is shown a greatly exaggerated position of a shaft caused by a low bearing. In this case the readings when the crank pin is in the top or "A" position will be greater than the readings when the crank pin is in the bottom or "C" position. In the event the connecting rod is in place when these readings are being taken, the crank pin can be slightly off the bottom dead center when taking "C" position readings so that the strained gauge or micrometers will clear the rod. A difference in readings when the crank is in the front or "D" position and back or "B" position will indicate possible horizontal misalignment of bearings. A shaft in this condition must be corrected, as it causes a reversing of fiber stresses in every revolution of the shaft. The magnitude of the fiber stress can be determined by the formula

$$P = \frac{43500 \times a \times t}{L^2}$$

Where:

P = the stress in lb. per sq. in.
a = maximum deflection in thousandths of an in.
t = thickness of the crank web, in.
L = one-half the stroke of the crank.

It is good practice to make sure that a shaft is being supported by all of its bearings. Some shafts, due to their stiffness, will show to be in perfect alignment, yet when put into operation under a heavy load may be "bowed." Bridge gauge readings will readily indicate whether or not the shaft will bow under loaded conditions. Fig. 12 illustrates one method of taking bridge gauge readings. First the crank adjacent to the main bearing journal being gauged is placed in a horizontal position. The gauge is set over the journal so that the micrometer pin is directly over the center of the shaft. The micrometer is adjusted until the pin touches the shaft and the reading is then observed. By means of a small jack placed on the crank web and against a timber placed in the "A" frame the main journal is forced downward. The micrometer is then again adjusted to touch the journal and the reading is noted. If the two readings vary, the indications are that the bearing is low in respect to the other bearings. If the second reading does not change, the journal is being correctly supported by its respective bearing. This procedure is repeated on all main journals. All bearings found to be out of alignment should be corrected, as this condition may lead to serious trouble. Main bearing shells do not always fit the bore in the bedplate of an engine. These should be checked with "bluing" and "lapped" into place.

A level on the main journals will readily indicate whether or not the shaft is level with respect to the bedplate.

It should be borne in mind, however, that no inspection or repair instructions will continue to be of maximum value without revision. From time to time new and improved methods and ideas must be continually developed. Periodic meetings of all persons interested in maintenance have been found very helpful. In these meetings the outlined and maintenance procedures are freely discussed. New methods are thus developed and put into practice. ——☆☆☆

Fig. 11. Showing exaggerated position of a shaft caused by a low bearing

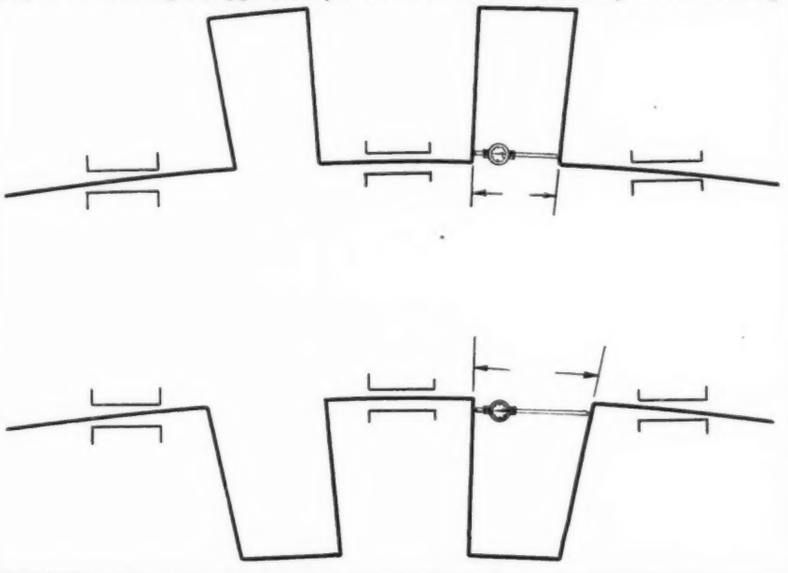
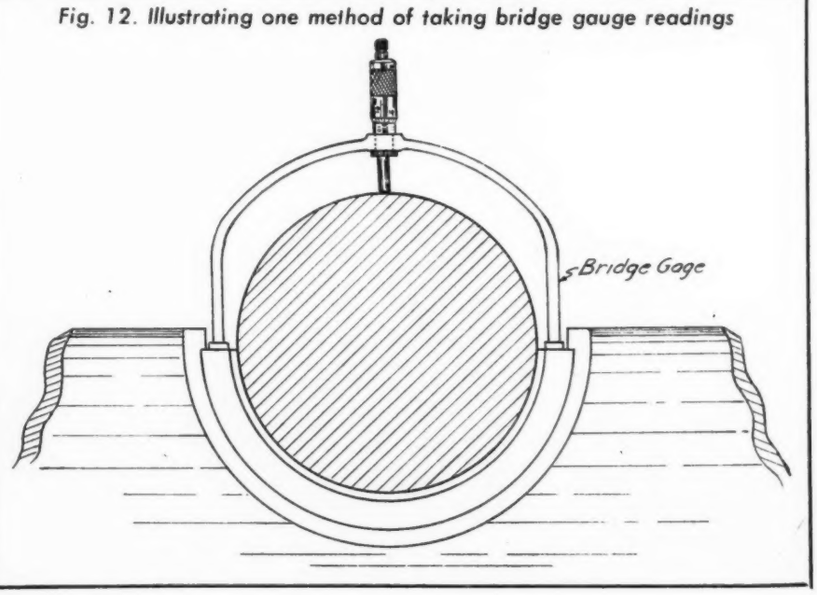


Fig. 12. Illustrating one method of taking bridge gauge readings



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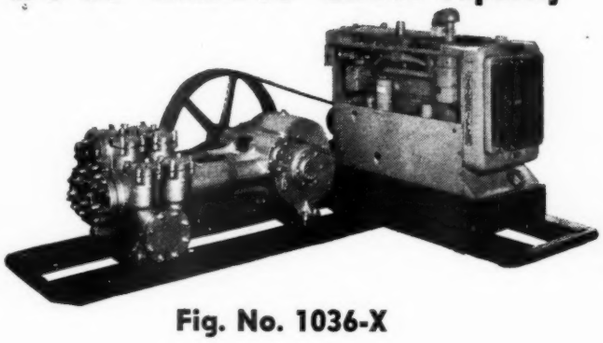

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4½"	228	5,486	340	37.2	100
5"	284	6,822	275	37.6	100
5½"	345	8,297	225	37.4	100
6"	412	9,874	190	37.6	100

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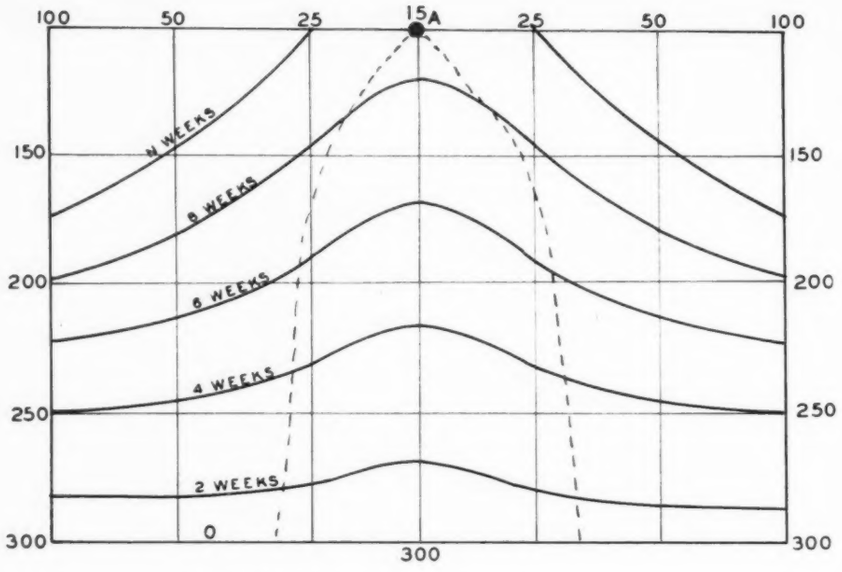

Fig. 1. Drawing showing the progressive movement of a water drive in a hypothetical case. Figures at the margin show the pressures at the beginning of the drive

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Secondary Recovery Receiving Greater Attention

Dwindling reserves and decreased rate of discovery stimulate need to increase ultimate recoveries from known reserves

by Charles H. Rankin

District Foreman, Continental Oil Company

SECONDARY recovery methods are receiving more attention each day as petroleum reserves are being depleted. Many plans for the extension of secondary recovery methods are held in abeyance pending the upward adjustment of crude oil prices and in the interim it is well to consider just what the best methods are and how they can best be applied to the problem of recovering the reserves of oil that cannot be recovered by natural means.

Secondary recovery methods fall into three general groups, namely: pressure maintenance, gas repressuring, and water flooding. Of these three methods there now seems to be little doubt that the first mentioned, pressure maintenance, will greatly increase the total amount of recoverable reserves if it is correctly applied early enough in the development of new fields to offset the natural decline of reservoir pressures.

Regarding the other two methods there seem to be some who regard them as alternative. In general, they are not. In many fields that have been repressured with gas there remain unrecovered reserves that can be brought to the surface by water flooding methods and in other fields that have a natural water drive, and have therefore not been adapted to gas repressuring, additional reserves could be produced by establishing a controlled and directed water drive.

CHARLES H. RANKIN

attended Colorado School of Mines, beginning in 1926—Employed by Geological Department of Continental Oil Company, 1929-35—Production foreman of Jesse area, 1936—Superintendent of Shiprock District, Shiprock, New Mexico, 1937-39—In 1940 became production superintendent of the Colorado District, Rocky Mountain Division—Made district foreman Electra area, Wichita Falls, District, 1942.

Reservoir Conditions

Before entering into a discussion of methods it is well to consider the conditions that exist in the reservoir when natural methods of recovery have depleted the sand to the point where they can no longer be profitably produced. If we magnify a cross-section of an oil sand we would have a picture similar in appearance to the diagram in Fig. 5. Eighty percent of the space would be taken up by the sand grains themselves; of the remaining space, part would be occupied by free gas, part by the connate water, and part by the oil remaining in the sand. The problem then is to displace the oil residue and to move it into the well bores from which it can be extracted. To displace the oil and to cause it to move we must exert pressure. This is done by introducing either gas or water under pressure. In the section shown it can clearly be seen that if

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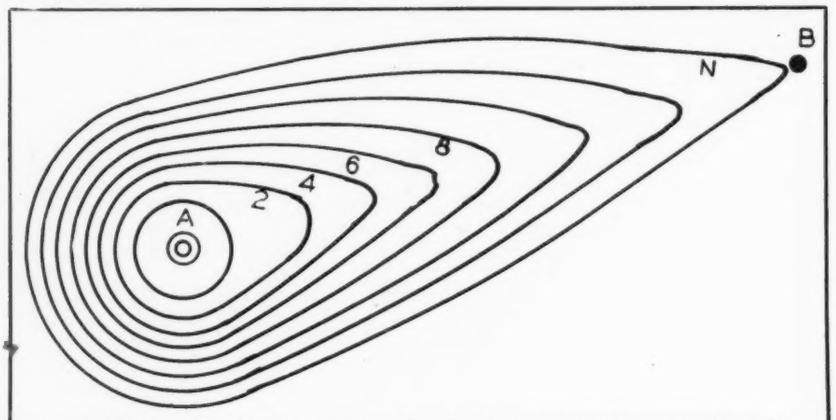


Fig. 2. The lines in this figure show the development of the water front in a project where water is introduced into well "A" and the oil is withdrawn from well "B"

either water or gas is introduced into the pore spaces under sufficient pressure it will displace the oil. To apply this problem in the field is a little more complicated and other factors must be considered. The thickness of the sand, both its lateral and vertical porosity and permeability, and the distances and spacing of the wells in which the pressure is applied and those from which the oil is to be recovered.

Elementary Principles

The elementary principles of hydraulics that govern the movement and flow of liquids are well understood. To move a liquid from one place to another it is only necessary to apply enough pressure to overcome the head and frictional resistance and then to allow enough time for the movement to take place under the existing conditions; it being understood of course that there are openings or channels through which the movement can take place.

Too often, factors governing the underground conditions are overlooked, such as the effect of the natural laws of gravity and the tendency of fluids to move in the paths of least resistance. In practice these two factors are very important. It can easily be seen that if we attempt to move a liquid through a pipe that runs uphill by means of gas pressure we will soon establish a condition wherein the gas will bypass the liquid and pass through the line without moving any liquid. Similarly, in an oil sand if the gas is introduced into the sand at a point that is structurally lower than the well from which it is intended to produce the oil, the gas will separate from the oil as a result of the difference in their specific gravities and flow into the bore without moving any oil.

In a similar manner a water-drive project that attempts to move oil down structure will fail because of the difference in specific gravity between the oil and the water. This does not always mean that a repressuring experiment conducted in violation of these principles will not produce results. Shale breaks and planes of separation in the sand may prevent the gas from bypassing the oil and force the oil to move with the gas into the bore despite the laws of gravity. The fact remains that greater results could be accomplished by utilizing the differences in gravity rather than in trying to ignore or overcome them.

Necessary Conditions

Having pointed out some of the most obvious pitfalls into which a secondary recovery project may fall, we then come to the solution of the specific problem. Before a project is attempted the following questions should be answered:

1. Can enough oil be recovered at the prices that now prevail or may be expected to prevail to pay for the cost of installing the necessary equipment and pay the costs of operation?

2. If additional wells will be required to consummate the project can their cost be added and paid out?

After it has been determined that the foregoing conditions can be satisfied a competent engineer should make a complete study and analysis including in his report the following:

a. Structure. What are the relative elevations of the sand in the wells on the property to be repressured; also what are the structural positions of the wells on the adjoining properties?

b. What is the porosity of the pro-

Fig. 3. A water-drive project in which water is introduced into wells A, B, C, and D and the oil is driven toward well E. The dashed line shows the area that would be flooded

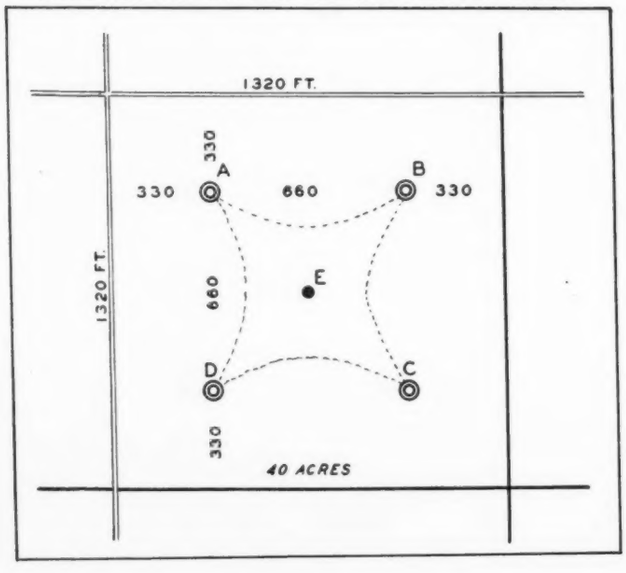
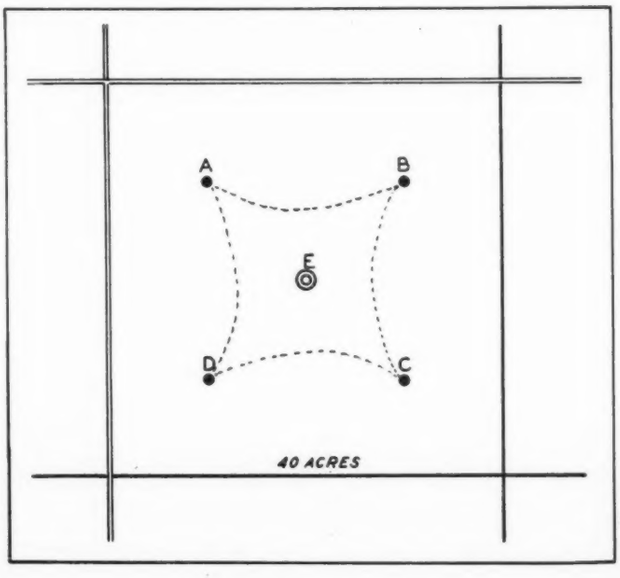


Fig. 4. Gas drive project in which gas is introduced into well E and oil is produced from wells A, B, C, and D



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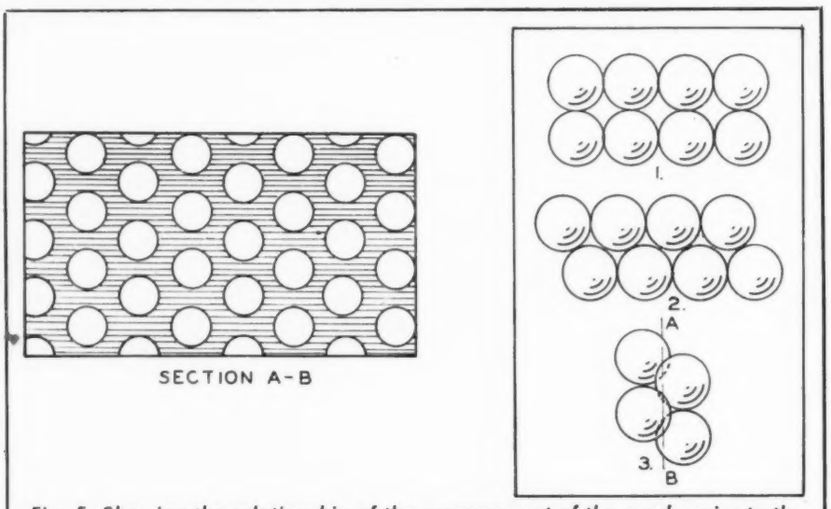


Fig. 5. Showing the relationship of the arrangement of the sand grains to the effective pore space. The section drawn through 3 would show the maximum pore area in a single plane. A section drawn through the centers of the grains would show the minimum area in a plane

ducing sand and how may it be expected to affect the success or failure of the project?

c. The percentage of connate water in the sand to be repressured should be determined if possible as it may affect the success of the project.

There are operators who can afford to gamble with many of the factors whose value is unknown, but if the project is to be an economic success each of the factors that will influence the migration of oil from the reservoir spaces into the well bores should be carefully evaluated before any attempt is made to exploit the reserves that may be expected to exist. Sometimes it is possible to weigh many of these factors by studying the results that have been obtained on nearby or offsetting leases.

d. The conditions of pressure both in the well bores and in the surrounding areas must also be considered. In the last analysis it is pressure and pressure alone that will bring about the desired fluid movements.

General Conditions

Before entering into a detailed discussion of the factors that have been mentioned it might be well to consider some of the general conditions that have been overlooked in many approaches to this complex problem. When an area is repressured by one means or another certain movements are expected to take place as the result of the application of pressures at a given point or points in a local area. In general this problem has only been considered by stating that here is a certain pressure and at another point, so many feet away, is another pressure and that if this condition exists fluids will move from point A to point B.

In practice the problem is not so simple and must be considered in the three dimensions and under the conditions in which it exists in nature.

The diagram, Fig. 1, illustrates a theoretical case. The problem is a water drive and the lines shown, 2, 4, 6, 8, etc., are drawn to show the front of the water drive at different periods of time after the drive is initiated.

At the beginning, line "O," water is introduced into a sand at uniform pressure, 300 lb. per sq. in. At the top of the figure, which would be north in a plan or map, is an opening, atmospheric pressure at one point that might be a well, and higher pressures at points on either side, away from the opening or bore.

The movement that would then take place would be the direct result of the differential pressures existing. The line labeled "2" would show the development of the water drive front at the end of two weeks, "4" at the end of four weeks, etc.

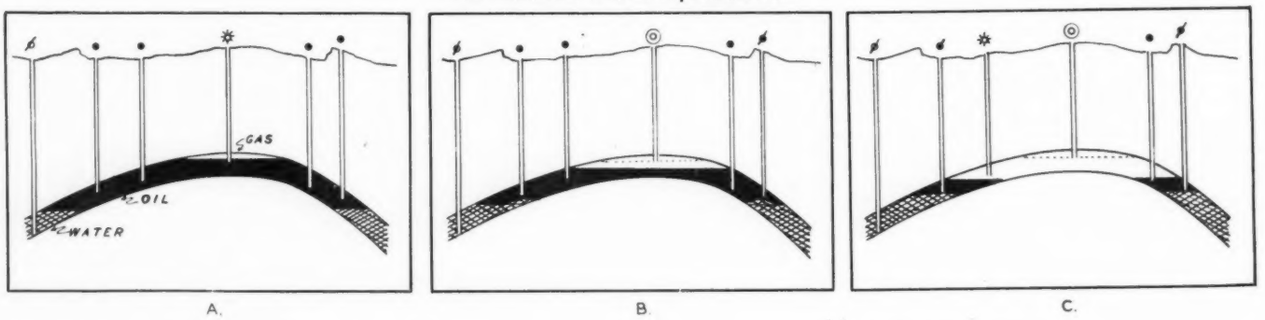
What would then be the result of this project. At the end of "n" weeks, the greatest movement having taken place in the direction of the lowest resistance, water would reach the opening or bore and a continuation of the process would only result in water being produced. Only that portion of the oil in the sand in the area included within the dashed line would have been forced into the bore ahead of the advancing water front.

Fig. 2 is a drawing showing the result of introducing water into a well at "A," and attempting to move the oil in the sand between the two wells into the well "B." In this case only a relatively small amount of oil would be produced before a channel had been established between "A" and "B."

A typical water-drive problem is illustrated in Fig. 3. In this case the water is introduced into wells "A," "B," "C," and "D" and the oil is driven into well "E." In this case a much greater percentage of the residual oil would be driven into the producing well. This is the general pattern followed in water-drive projects. Key wells are selected at points surrounding the output well and it is attempted to drive the oil remaining in the sand into the central well.

A gas repressuring project is usually organized along the lines shown in Fig. 4, which attempts to force the oil to move with the gas from a central well into the surrounding wells. This is a quite natural attempt to simulate the condition that existed in the sand before any wells were drilled and to restore the

Fig. 6. A, B, and C show the progressive development of a gas drive in an anticlinal structure where gas is introduced at the top of the structure. These figures illustrate how a maximum recovery of oil could be obtained with a minimum of water production



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original formation pressures that first induced the oil production.

In the planning of any project it must be kept in mind that in plans such as shown in Figs. 3 and 4 there is a third dimension, depth, that must also be taken into account.

Any oil sand or oil-producing formation will vary greatly in porosity at different depths and this variation will have an important bearing on the manner and path that the repressuring medium will follow in moving from a high-pressure area to one of low pressure.

The greatest movement will take place in the path of the greatest permeability and oil in the less permeable parts of the sand is likely to be left behind when movement is established.

If there are breaks between the zones of high and low porosity it is sometimes possible to control the movement by setting packers and applying different pressures to the various parts of the sand. If the zones of different permebility are not separated there remains only one way in which we can attempt to offset the variations and that is by using the time element.

If great pressures are applied at the injection well, movement will be correspondingly accelerated. If only nominal pressures are employed, however, the movements will take place at a slower rate and this will allow the movements through the tighter zones to "catch up" with the flow in the more porous layers. This catching up can only be relative as the rate of flow will still be proportional to the permeability but the resistance of a tight member will be less proportionally at the lower rate of flow than will be the case in the more porous zone. By definition, the unit of permeability, the Darcy, is the result of the solution of a differential equation in which time is a factor.

In the solution of the permeability problem, if the rate of flow and the differential pressure become very small then the relative differences in permeability in different media become correspondingly less.

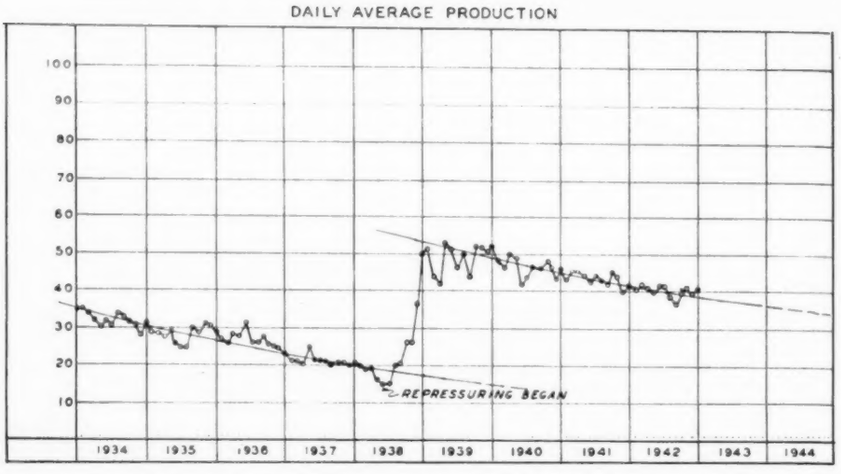


Fig. 8. Graph of the daily average production of the lease in North Texas showing the increase in production brought about by water flooding

Thus to obtain the greatest efficiency of recovery in a given project the time element must be considered in computing the efficiency of recovery that it is expected to obtain. In simpler terms, the greater percentage recoveries can be obtained in sands having vertical variations in porosity if enough time is allowed to elapse to permit the extraction from the tighter parts of the formation. Maximum efficiency must be weighed against a time factor that will be compatible with the economics of the conditions and costs of each case.

As an example: In a certain case where a water drive is initiated, we can obtain 50,000 bbl. in one year by using injection pressures of 500 lb. per sq. in. In this same project, however, we might obtain 85,000 bbl. in two years by using pressures of only 250 lb. If we drop the injection pressures to 100 lb., however, it might require five years to recover 50,000 bbl.

Each project is an engineering problem and the best methods to be followed can be determined by applying engineering concepts of efficiency and economy.

Pressure Maintenance

Pressure maintenance has been accepted in the last few years as a recognized means of increasing the total amount of recoverable oil and prolonging the life of flowing wells in newly developed fields. This has become especially important in fields where production has been found at depths in excess of 6000 ft. When these deeper fields were discovered it was recognized that it would be costly as well as exceedingly difficult to produce oil from wells more than 6000 ft. deep by artificial means, such as pumping. To forestall this condition it was proposed to extend the flowing life of the wells by returning the gas produced with the oil to the producing formation where it would tend to maintain the original formation pressures and prolong the flowing life of the wells.

In the Gulf Coast area of Texas, where many of the deeper fields are, this practice has been followed extensively

Fig. 7A. Plat of the lease in North Texas before water drive was initiated

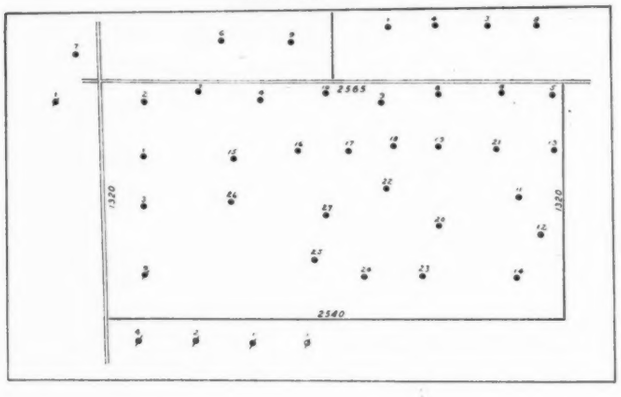
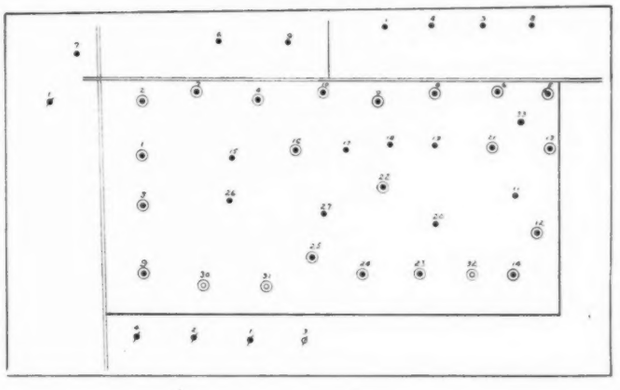


Fig. 7B. Plat of same lease showing location of key wells in water-drive project



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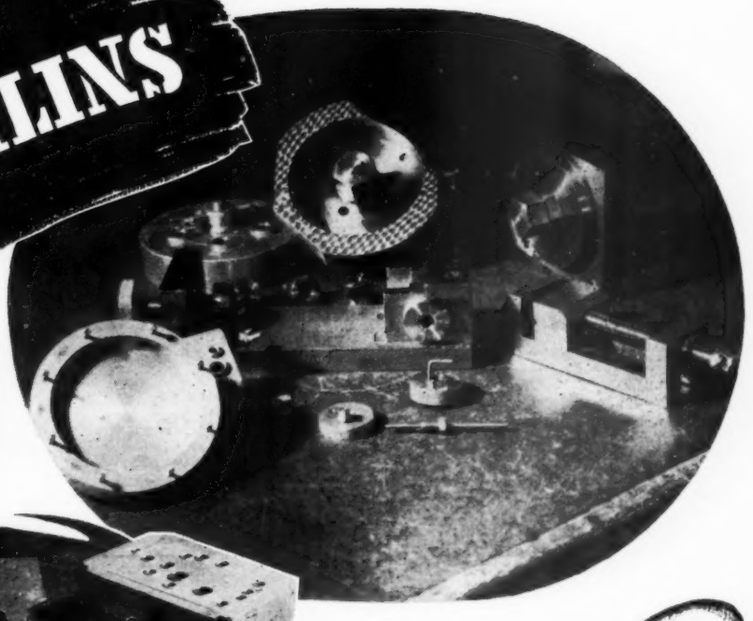

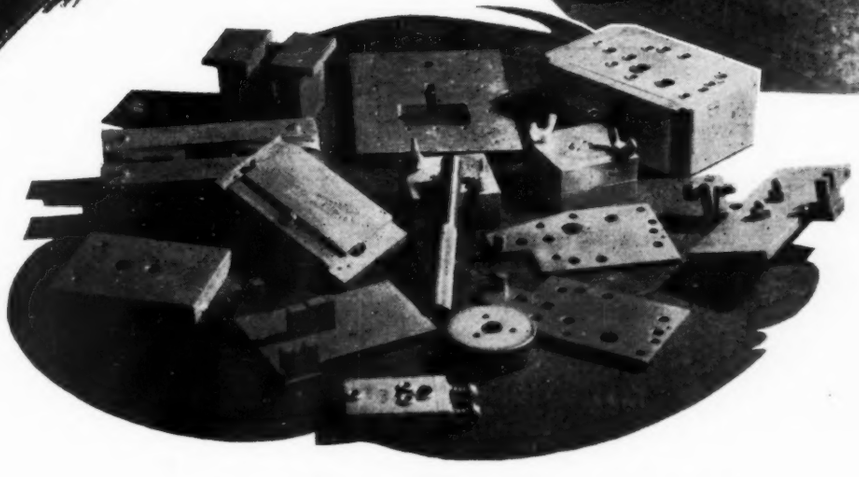

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REPRESSURE PROJECT No.

Lease Section County
Acres No. Oil Wells No. Shut Down Wells
Daily Average Production Oil Cumulative Bbl.
Daily Average Production Water Per Acre to Date
Daily Average Production Gas
Sand Thickness Depth
Porosity Permeability Connate Water

Present Lifting Cost
Per Bbl. Per Month

ESTIMATED COSTS

Repressure Plant Lines Required
Equipment . . . . Feet Cost
Foundations . . . Wells Required
Buildings . . . . . Number Cost
Total . . . . . Reconditioning Costs
Total Investment Required . . . .

PAY OUT

Estimated Gain in Prod'n: 1st Yr., 2nd Yr., 3rd Yr.,
Total Estimated 5 Year Recovery: Bbl. Worth
Lifting Cost Including Repressure Per Bbl.
Lifting Cost Including Repressure Per Month
Pay Out Gain Per Month Length of Time to Pay Out
Overall 5 Year Profit

Remarks:

Fig. 9. Form used for the study of repressuring projects

and with considerable success. The oil is found in sandstones having favorable permeabilities and even though the injection pressures have been high the results have been profitable.

The greatest and most favorable results have been obtained in fields of the anticlinal type where the gas is introduced into the top of the structure. There, it tends to form a gas cap, driving the oil down the dip where it is produced from wells above the water level. This pressure in addition to stimulating the production of oil retards the ingress of water and if the formation pressures are adequately maintained, all recoverable oil in the structure can be produced without the necessity of handling large volumes of water as has been the case where the bottom-hole pressures have been allowed to decline as the result of the withdrawal of both oil and gas from the structure.

Fig. 6 (A, B, and C) shows the development of the extraction from a pool where pressure is maintained by the introduction of gas into the top of the structure.

In certain other areas, particularly those in the Mid-Continent, where the dips are very low, some success has been achieved in pressure-maintenance projects although greater results could have been obtained in some projects if the structural conditions had been taken into consideration in locating key wells. In some of the larger fields it has been impossible to maintain a gas drive because it has been necessary to locate the key wells over too wide an area. In these projects considerable quantities of oil are going to be lost as the result of channeling from the key wells into nearby producers. When such channeling takes place it is difficult, if not impossible, to restore the natural movement of oil through the sand, and the oil that has been bypassed is lost.

North Texas Water Flood

Fig. 7 (A and B) shows a North Texas lease that was water flooded in 1938. Twenty-nine wells had been drilled on this lease, having an average depth of 1200 ft. The cumulative production to January 1, 1938, was 253,000 bbl. The daily production on the lease had declined from a high of 125 bbl. daily in 1929 to 20 bbl. daily in 1938.

Before it was finally decided to attempt the project, well No. 30 was drilled and complete cores of the producing sand were taken. It was found that the sand body was about 25 ft. thick although it changed at both the top and bottom from solid sand to interbedded sand and shale. Of the entire 25 ft. only about 10 ft. was good, porous sand and this 10 ft. was in two breaks, one 4 ft. in thickness and the other almost 6 ft. Studying the old logs of other wells in the field showed that many breaks had been logged in the sand in different parts of the field and some wells had only been drilled into the uppermost part of the sand. Well No. 31 was drilled and cored through the sand and it too showed great variations in porosity and had three porous sand bodies that did not seem to correlate closely with the breaks found in well No. 30. This made it seem doubtful that a water drive would be successful but it was decided to attempt it and the plant was installed early in 1938. A total of $24,650 was invested in the plant. The engine and pump required were purchased second hand for $1900, a building to house them and their foundations cost another $1000. Three additional wells, including the two mentioned, were drilled and cased for $9000. Lines, tanks, and a filtration plant brought the total cost to the figure mentioned.

It was almost six months from the time the plant was placed in operation before an appreciable improvement in the production was evident but at the end of the year the lease was producing 50 bbl. daily.

Fig. 8 is a graph showing the daily average production from this lease plotted by months. Since the project was installed it has more than paid for itself and it now appears that the ultimate production per acre from this lease will be close to 5000 bbl. per acre instead of the 4000, which it appeared would be the ultimate in 1938.

Fig. 9 is a reproduction of a form the writer has used in studying waterflooding and repressuring projects.

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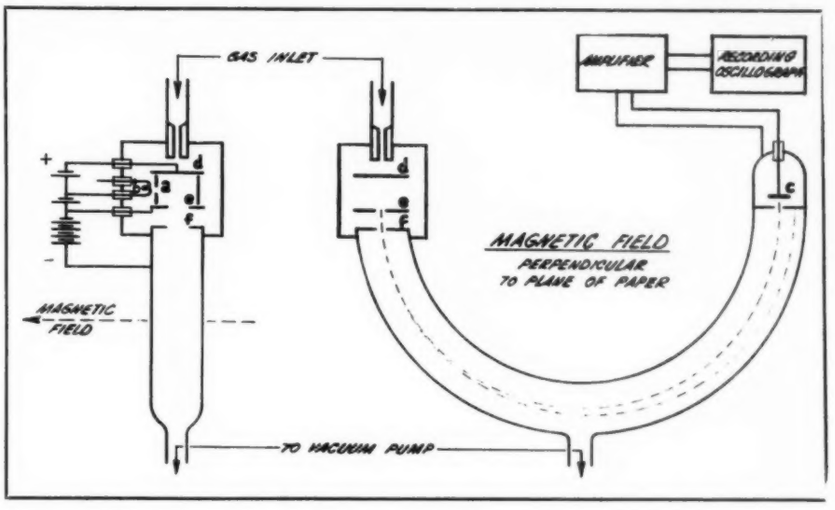
Fig. 1. Diagrammatic sketch of mass spectrometer



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Quantitative Analysis by Mass Spectrometry

☆ Wide applicability of instrument in plant control seen for future

by O. L. Roberts

Research Supervisor, The Atlantic Refining Company

PARTICULARLY in the field of hydrocarbons, the last few years have seen many attempts to provide new or improved methods of analysis. Much thought and effort have been devoted to the development and improvement of methods such as atmospheric and sub-atmospheric pressure distillation, selective solvent extraction, selective adsorption, fractional crystallization, and other physical methods that employ the use of densities, refractive indices, etc. Infrared and ultraviolet absorption and the Raman effect have been put to use in the examination of relatively simple mixtures and for such mixtures these methods have proved to be very satisfactory. Infrared analysis is the most versatile of the three methords but it is limited to the C_1 to C_5 hydrocarbons. Sporadic attempts have been made during the last 8 or 10 years to use the mass spectrometer as a quantitative instrument in analysis but only during the last two or three years has it been possible to analyze samples of any appreciable complexity in a quantitative manner by means of this instrument.

The mass spectrometer has quite satisfactorily analyzed quantitatively samples containing a dozen different components. Its range of usefulness in its present form of development can be said to extend to all mixtures whose components are fully vaporized at a pressure of 30 to 40 microns at atmospheric temperature. The limitation that prevents the spectrometer from being used over this entire range at present is the lack of pure compounds necessary for the calibration of the instrument. When these calibrations are available the full range of the instrument can be utilized. This range, when realized, greatly exceeds the possibilities of any other single method of analysis by such a large margin that one may consider the mass spectrometer to be the most useful analytical tool.

The possibilities of the mass spectrometer as a control instrument in plant processes will probably be realized in the near future. It should be possible through a manifold system to bring samples from a number of different plant units into a central instrument and through a suitable automatic device to have each sample periodically pass through the spectrometer and have its pattern recorded. Inspection of these patterns by a trained interpreter would enable instructions to be given to the plant operator almost as soon as the

O. L. ROBERTS

possesses A.B., M.S., and Ph.D. degrees, and before going with the Atlantic was an instructor at Pennsylvania State College—The last 12 years has been with the Atlantic Refining Company as research supervisor, actively engaged in physical and physico-chemical problems dealing with refining and producing work—Much of the work has dealt with solvent extraction, cracking, high-pressure distillation, K-values of hydrocarbons, condensate recovery from high-pressure fields, and flow of fluids in reservoirs.

TABLE I
C_1-C_4 paraffin, olefin synthetic
Mol percent

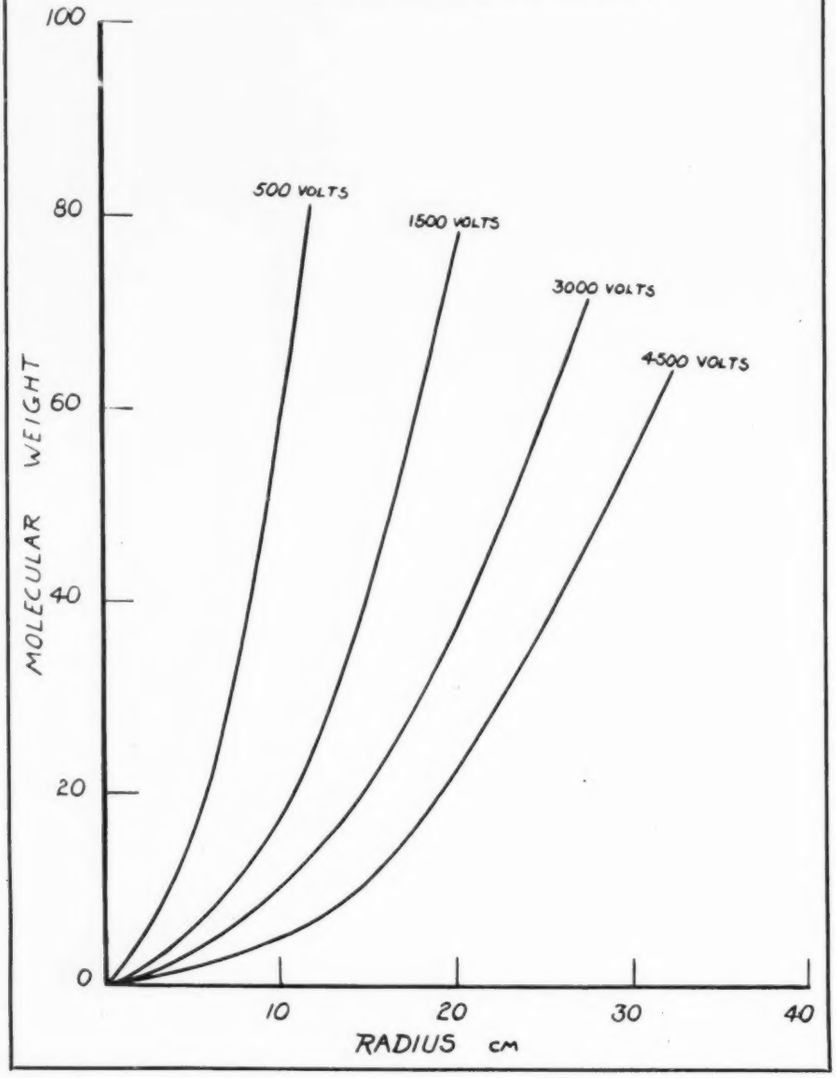
	Manometer	Mass spectrometer
Methane	11.3	10.9
Ethylene	1.5	1.7
Ethane	22.1	21.4
Propene	11.9	11.8
Propane	31.1	31.0
Isobutane	5.0	5.0
Isobutene	4.4	4.7
Butene -1	5.0	6.2
Butene -2	0.7	0
N-butane	7.0	7.3

	Complete analysis	Normal, isobutane, total butenes
Man hours	3¼	¾
Elapsed time	2hr. 50min.	¾

pattern is made. In some instances, where the composition in terms of a single component is the deciding factor in plant control, an automatic device could be provided to make the adjustments without manual control. In such a case a relatively inexpensive and simplified spectrometer could probably be used.

The use of the mass spectrometer in understanding chemical reactions is another important application of the instrument. If, for instance, in the alkylation reaction the operator is interested in knowing whether there is an exchange of hydrogen between the reactants and the acid catalyst it should be possible to prepare the catalyst from heavy hydrogen and determine the presence or absence of heavy hydrogen in the reaction products. This type of tracer study has been used in biological reactions and found to be very helpful in understanding the mechanisms involved. Furthermore, inasmuch as the molecules suffer fragmentation in passing through the mass spectrometer a study of proportions of the various fragments obtained from various parent molecules should yield information concerning the relative stability of the bonds within the molecule.

Fig. 2. Relation between ion accelerating potential, molecular weight, and radius of curvature for fixed magnetic field strength



Principle of Operation

If a mixture of sand grains of different size is blown through a horizontal nozzle with a blast of air it will be found that due to the combined action of the air blast and the force of gravity that the heaviest grains will be deposited closest to the nozzle of the air blast and the lightest grains will come to rest at the greatest distance. The grains having intermediate masses will be deposited at intermediate distances. In the case of the mass spectrometer the molecules and the fragments of the molecules differ in mass and by electrical means they are given a velocity that is the counterpart of the horizontal velocity given to the sand grains. A magnetic force causes a deflection of each of the molecules or fragments and the magnitude of the deflections will depend upon the mass of these molecules or fragments. The magnetic force corresponds to the force of gravity in the sand analogue. This analogy cannot be carried too far but it assists in illustrating the principle employed in the mass spectrometer.

In Fig. 1 (b) is a metallic filament that is electrically heated. As in the case of all heated bodies electrons tend to be liberated from them. If the temperature of the object is sufficiently high electrons escape from the body and tend to form an electron cloud surrounding it. (a) is an electrode placed close to the filament, which is positively charged and which attracts the liberated electrons from the heated filament. As the electrons move toward the positively charged electrode they gain in velocity or, in other words, they become accelerated. A slit in the electrode (a) permits those electrons that are moving toward the slit to enter the region behind the electrode. The gas molecules of the sample are admitted through a leak system into the chamber in which the electron stream is defined. As they traverse the zone in which the electrons are traveling some of them are struck or bombarded by the high-speed electrons. The collision of the electrons with the molecules results in the production of charged particles called positive ions. For example, if a stream of butane molecules is admitted into the ionization chamber some of the butane molecules will be struck with electrons having only enough energy to dislodge an electron from the molecule, thus leaving a positively charged butane ion. Other molecules of butane will collide with electrons having sufficient velocity to disrupt or produce fragmentation of the molecule. As a result positive ions having the following structures will be formed in various proportions: C_4H_9, C_4H_8, C_4H_7, C_4H_6, C_4H_5, C_4H_3, C_4H_2, C_4H, C_4, C_3, C_2, C_1, C_3H_7, C_3H_6, C_3H_5, C_3H_4,

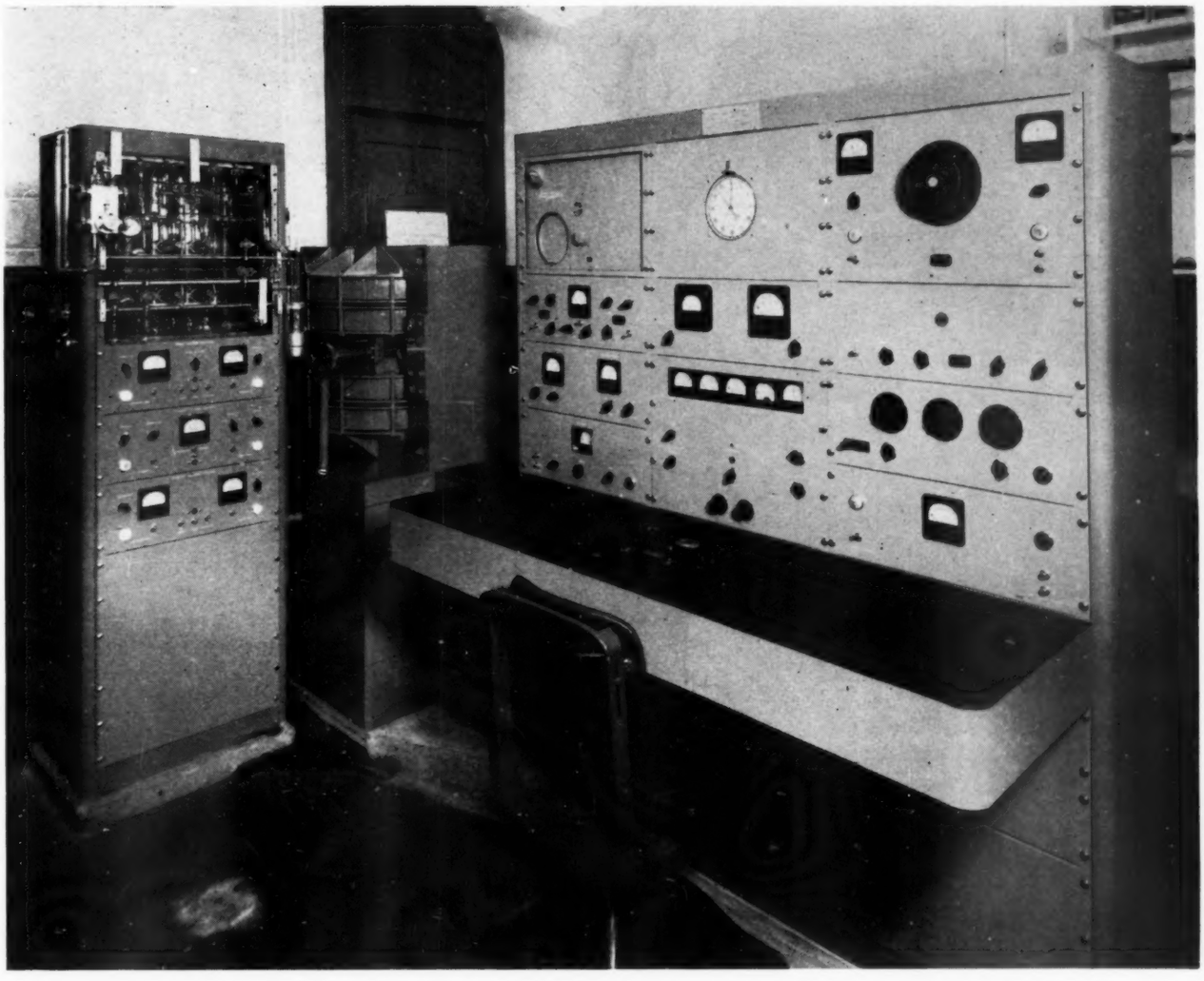


Fig. 3. Front view of instrument in use in Philadelphia laboratory of The Atlantic Refining Company

C_3H_3, C_3H_2, C_3H, C_3H_5, C_2H_4, C_2H_3, C_2H_2, C_2H, CH_3, CH_2, CH_1. The amount of some of these ions that are formed may be negligible, whereas the amount of others may be very considerable.

These positively charged ions are attracted toward electrodes (e) and (f), which are negatively charged. As the ions travel toward these electrodes they become accelerated and those traveling toward the slits in these electrodes pass through and enter the semi-circular tube called the analyzer tube. Inasmuch as an externally applied magnetic field surrounds the analyzer tube the positive ions are deflected. The direction of the magnetic field is such that it is perpendicular to the plane of the analyzer tube. All ions of a given mass will undergo the same deflection and each stream of ions of a given mass will describe a semi-circular path. Those ions of the lightest mass will describe a circle having the smallest radius of curvature, whereas those ions of heaviest mass will describe a circle having the largest radius of curvature. If the adjustment of the negative potential on the ion accelerating electrodes (e) and (f) and the magnetic field strength is properly adjusted some one stream of ions will have the proper radius of curvature so as to enter the slit at the other end of the analyzer tube and impinge on the collector plate (c). Through an amplifier and a recording oscillograph the change in potential of the collector plate is automatically recorded. By maintaining a fixed magnetic field strength and varying the negative potential on the ion accelerating electrodes the various streams of ions each of which has different masses can be focused or made to pass through the slit and impinge on the collector plate. In this way the relative amounts of ions

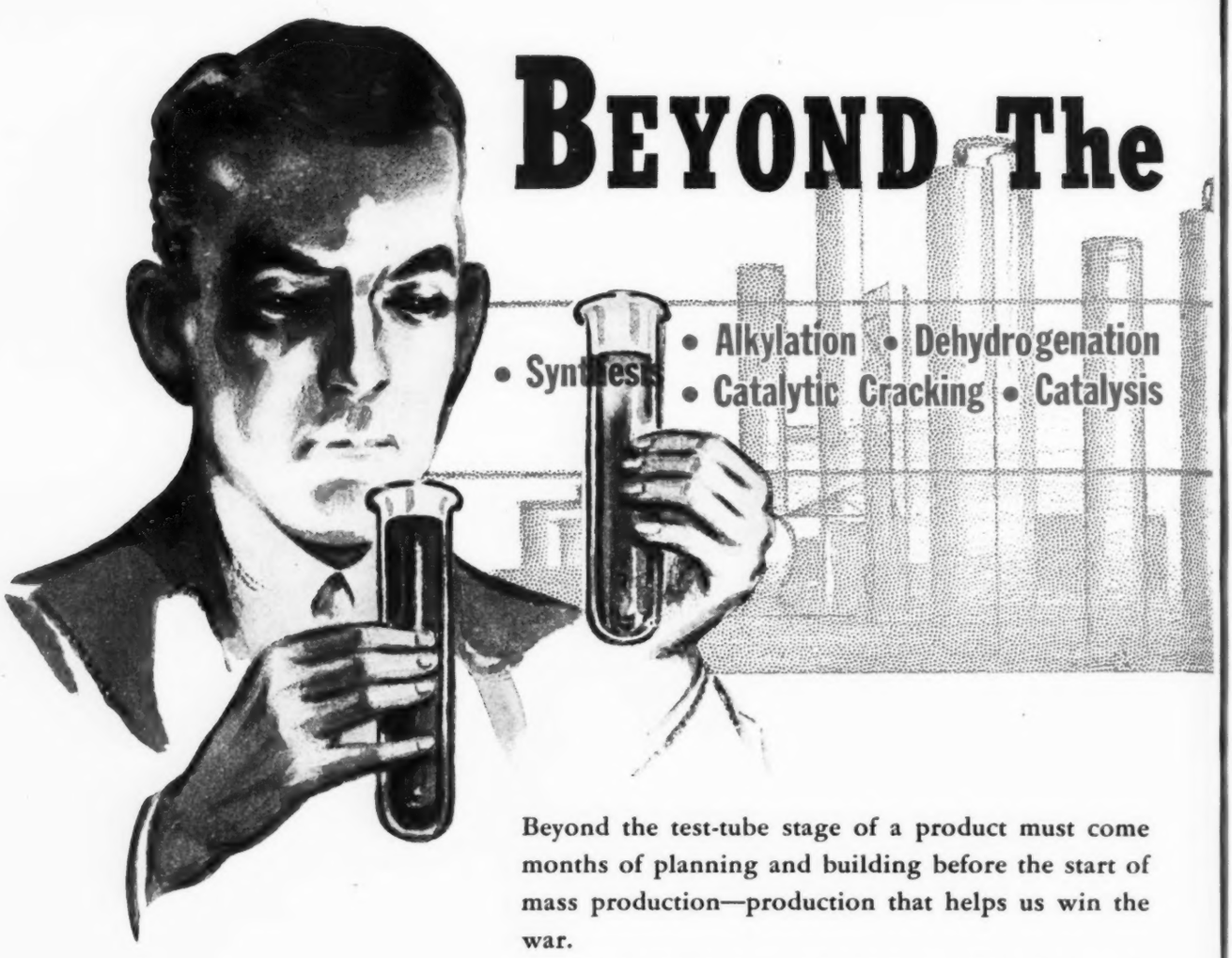
(Continued on Page 114)

TABLE 2

C_4 paraffin, olefin, diolefin synthetic

Mol percent

	Manometer	Mass spectrometer	Manometer	Mass spectrometer	Manometer	Mass spectrometer
Propane	0.9	0.4	0	0	0	0
Butadiene	66.6	67.2	92.6	92.5	3.8	3.8
*Iso*butane	0	0.6	0	0	0	0
*Iso*butene	0.9	1.0	0	+0.2	30.4	28.9
Butene -1	7.1	8.1	1.9	2.0	31.4	29.2
Butene -2	6.9	5.5	5.5	5.3	34.4	38.1
n-Butane	17.6	17.2	0	0	0	0
				Complete analysis		Butadiene only
Man hours				3¼		35 min.
Elapsed time				2 hr. 50 min.		35 min.



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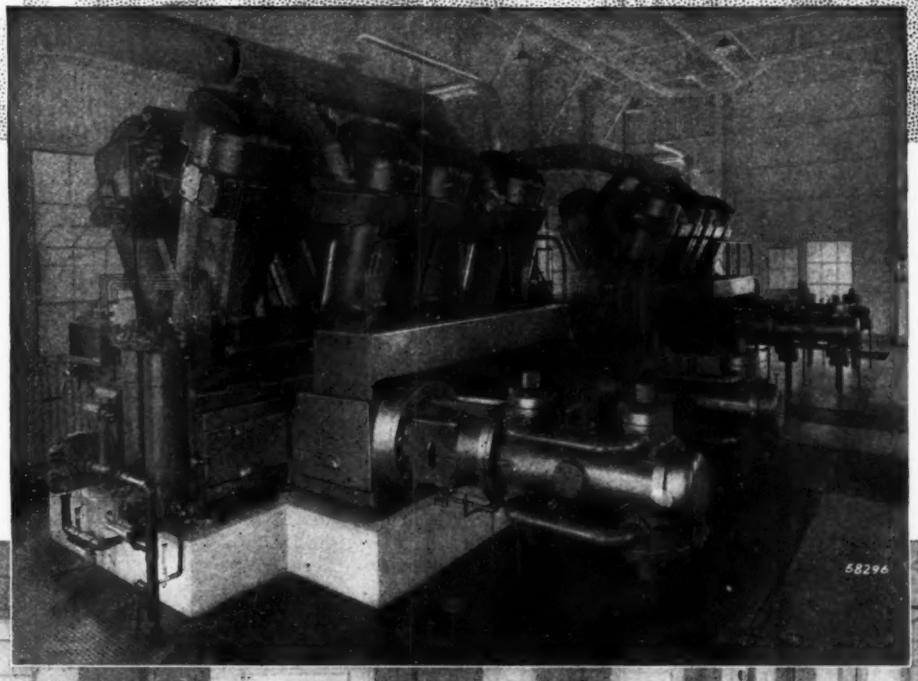

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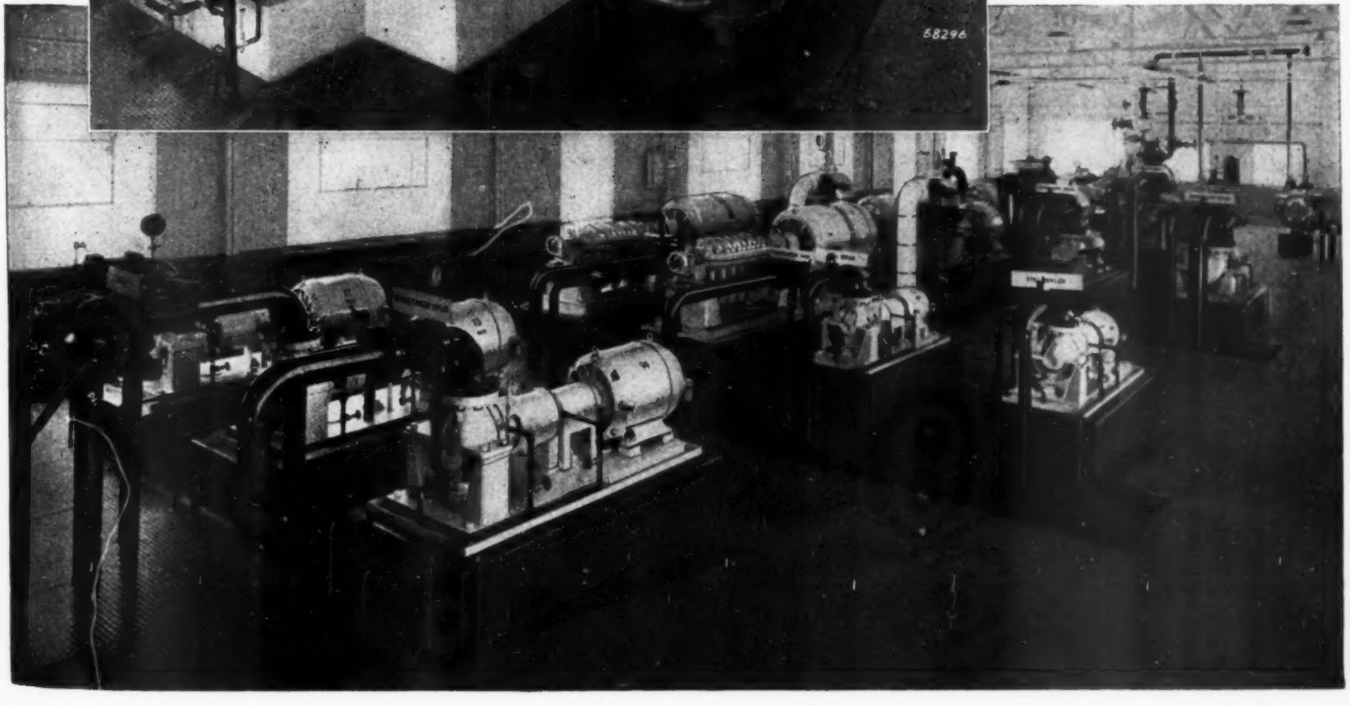


(Continued from Page 111)

having a different mass can be determined. In actual operation the magnetic field strength is maintained constant and the potential of the ion accelerating electrodes is automatically varied to successfully bring into focus each stream of ions of different mass.

The cause of the deflection of the positive ions by the magnetic field is the same as the cause of the deflection of a wire carrying an electric current when it is placed in a magnetic field. The positive ions when in motion constitute an electric current and are therefore surrounded by a self-induced magnetic field. The interaction between this induced field and the external magnetic field results in the deflection. The ions having the smallest mass are accelerated by the ion accelerating electrodes to a greater extent than are the ions of largest mass. Consequently, the ions of smallest mass constitute a current of greater strength than do the ions of the largest mass. This in turn means that the self-induced magnetic field surrounding the ions of smallest mass is greater than the magnetic field induced by the ions of largest mass. The interaction, then, between the externally applied magnetic field and the induced magnetic field will be greatest for the ions of smallest mass. The result is a greater deflection for the smallest mass ions, accentuated by the fact that the ions of smallest mass require the least amount of interaction force to bring about a deflection of a given magnitude.

It was stated above that the ion streams of different mass could be brought into focus by varying the ion accelerating electrode potential. The fact is that as the ion accelerating electrode potential is decreased the heavier ions are made to describe circles of smaller radii. The reason for this is as follows: If at the time the positive ion is formed its velocity be considered as zero, and if at the time the ion has traveled to the negatively charged ion accelerating electrode its velocity is (v), then the gain in kinetic energy is

TABLE 3

C_4 and C_6 paraffins, cyclics, and aromatics

Mol percent

Hydrocarbon	Fractionation (100 plate) column	Ultra-violet absorption	Mass spectrometer
Pentanes	3.8	..	3.7
2-2 Dimethylbutane	14.0	..	15.0
Cyclopentane	1.6	..	2.0
2-3 Dimethylbutane	9.4	..	7.7
2-Methylpentane	33.0	..	32.2
3-Methylpentane	13.9	..	14.6
n-Hexane	12.8	..	13.5
Methylcyclopentane	8.7	..	9.3
Benzene	2.9	2.0	2.1

10 man hours
9 hours elapsed time

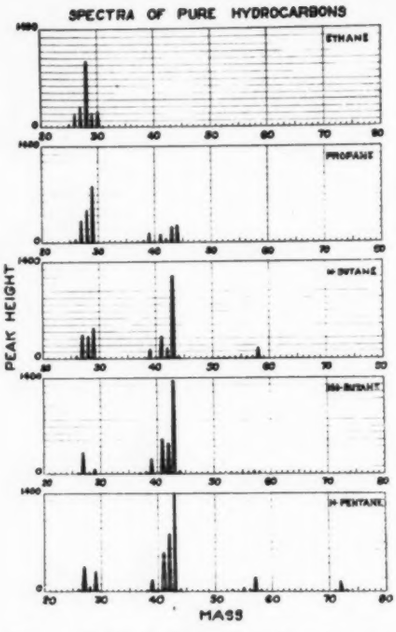


Fig. 4. Each hydrocarbon has its own characteristic spectrum

$\frac{1}{2}$ mv^2, where (m) is the mass of the ion. This gain in kinetic energy must be equal to the electrical work done in moving this charged particle and is equal to eE where (e) is the charge on the ion and E is the potential of the ion accelerating electrode. That is to say:

$$eE = \frac{1}{2} mv^2.$$

As the ions traverse the circular path they are subjected to two forces that are equally balanced. One is the magnetic force causing the deflection and the other is the centrifugal force acting on the ion. The magnetic force is Hev where (H) is the magnetic field strength, (e) is the charge on the ion, and (v) is its velocity. The counterbalancing centrifugal force is

$$\frac{mv^2}{r}$$

where (m) and (v) have the connotation given above and (r) is the radius of the circle being described by the ion in motion. As these two opposing forces are balanced

$$Hev = \frac{mv^2}{r}$$

Fig. 2 shows the relation of the molecular weight of the ions, the radius of the circular paths they describe for various ion accelerating voltages when an external magnetic field of fixed strength is applied. As the instrument has a fixed diameter analyzer tube, each stream of ions must be focused so as to have the same radius of curvature when the intensity of each ion stream is measured. From Fig. 2 it can be seen that in order to bring into focus ions of increasing molecular weight the ion accelerating voltage must be decreased and the relation between the ion accelerating voltage and the molecular weight of the ions for a fixed radius of curvature can be seen from the curves.

Principles of Construction

All details of construction have as their primary objective the production of spectra that are not only reproducible but which are a true summation of all of the peaks obtained from each component. In order to obtain these objectives the instrument has to be equipped with an ionization chamber that does not introduce spurious effects. It must be supplied with very constant currents and voltages. It must also have a closely regulated vacuum system. Fig. 3 shows a front view of the commercial instrument in use in the Philadelphia laboratory of The Atlantic Refining Company. This is the first commercial instrument in use in any industry that is capable of making quantitative analyses of complicated mixtures. The cabinet at the left houses the gas inlet system and the equipment for maintaining constant vacuum in the gas inlet system. Between the two cabinets is the electro-magnet that supplies the magnetic field for deflecting the ion beams. The analyzer tube is placed in a horizontal position between the pole faces of the magnet. The ionization end of the analyzer tube is connected to the gas inlet system through a capillary leak. The vacuum in the analyzer tube is maintained and regulated by a separate pumping system attached to the cabinet surrounding the magnet support. The large cabinet on the right is chiefly a housing for the power supply and regulating units. In the upper lefthand corner of the cabinet the recording oscillograph is mounted on a shock-proof mounting. The control panel of the cabinet permits the operator to calibrate the various instruments, to determine the currents and voltages in various parts of the circuit and to adjust the currents and potentials. Direct current is used in both the analyzer tube and the electromagnet.

TABLE 4

Gasoline + aromatics-synthetic

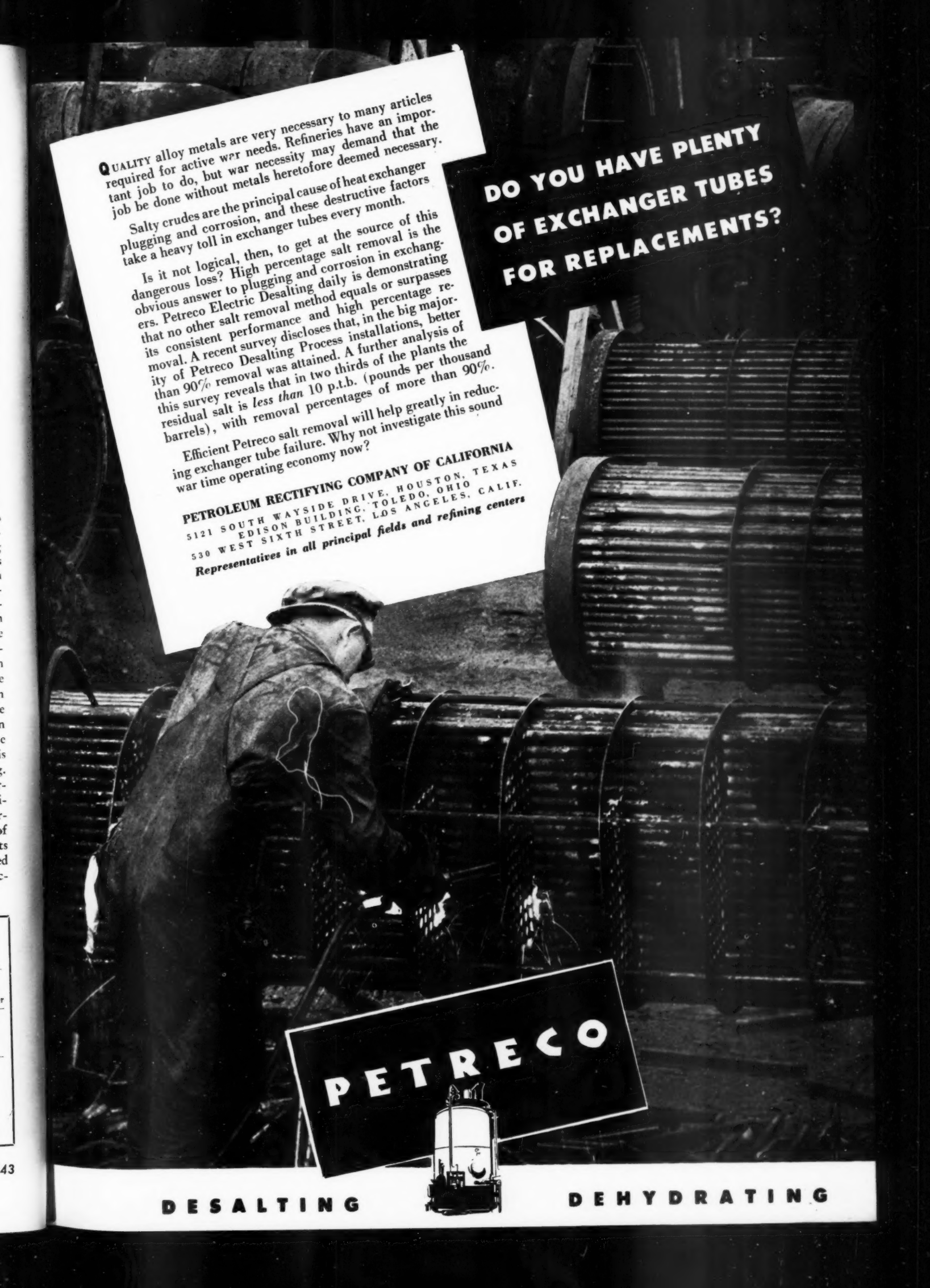
Mol percent

	Synthetic	Mass spectrometer	Synthetic	Mass spectrometer
Non-aromatics	49.1	49.1	52.9	55.0
Benzene	12.7	12.5	5.7	5.7
Toluene	37.9	38.4	21.0	21.8
Xylene	....	....	20.3	17.5

Non-aromatics in above mixture:

n-Hexane	n-Heptane
2-Methylpentane	Methylcyclohexane
2, 3-Dimethylbutane	"Isooctane"
Methylcyclopentane	"Isooctene"
Cyclohexane	

2¾ man hours
2¾ hours elapsed time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General Procedure

About one-tenth of a cubic centimeter of gaseous sample is admitted into the gas inlet system, which is maintained at room temperature and at a reduced pressure. It flows from this inlet system through a capillary leak into the ionization chamber and then out through the analyzer tube evacuation system. The magnetic field is adjusted by regulating the current that energizes the magnet. The current through the electron emitting filament, the electron accelerating potential, and the ion accelerating potential are adjusted to bring into focus the lowest molecular weight ions. The recording oscillograph system is put into operation and it automatically records the spectrum as the potential on the ion accelerating electrodes is reduced. This reduction of ion accelerating voltage is done automatically. The total time elapsed, beginning with the introduction of the sample to the completion of the record, is only a matter of 5 to 10 minutes, depending upon the experience of the operator. Development and fixation of the photographic record requires one to two minutes.

Interpretation of the Record

Each hydrocarbon has its own characteristic spectrum. (See Fig. 4.)

The abscissas represent mass and the ordinates refer to the relative amounts of ions of each mass. Normal and *iso*-butane spectra show the same peaks but the ratios of the heights of peaks differ sufficiently to make analysis possible. Differences of this nature enable isomers of the various hydrocarbons to be determined. In the case of certain hydrocarbons there are peaks that are characteristic of a hydrocarbon. The height of these peaks is directly proportional to the concentration of the hydrocarbon responsible for these peaks. Consequently, if the spectra for pure hydrocarbons are known, the presence of certain peaks in the spectrum of a mixture indicates the presence or absence of the individual hydrocarbon and the height of the peaks indicates the amount of hydrocarbon present in the mixture. To use a concrete example, let it be supposed that a mixture contains methane, ethane, and propane, in equal proportions. The parent peaks for each of these hydrocarbons occur at masses 16, 30, and 44. If the spectrum of the mixture is obtained under identical conditions, as were the spectra for pure methane, ethane, and propane, then the heights of the 16, 30, and 44 peaks of the mixture spectrum will be exactly one-third the heights of the corresponding peaks for the pure hydrocarbons. In the case of isomeric hydrocarbons characteristic peaks will be lacking, but a knowledge of the ratios of the heights of the peaks obtained from the pure hydrocarbons enables the calculator to determine how much of each isomer is present.

Taking into account various types of analyses that confront the refiner, it is estimated that an experienced operator and calculator can average one sample in about two to three hours' time. Many of the mixtures will require less time and others may require much more time. On the other hand, if the instrument is to be used for running determinations on the same type of sample the average total time of running and calculations can probably be reduced to about an hour. During the operation of the instrument four or five check spectra can be obtained from the same sample and the average of the heights of the peaks from these check spectra can be used for obtaining an average set of results. The additional time involved in procuring these check patterns is only a matter of a few minutes. The gas inlet system is provided with containers for pure calibrating gases so that the spectra of these gases can be obtained immediately prior to or immediately after running the mixture. This enables the operator to make sure that the mixture was run under identical conditions with the calibrating gases.

Examples of Analyses

The instrument has been calibrated for a variety of compounds including hydrogen, oxygen, nitrogen, carbon dioxide, hydrogen sulphide, methane, ethane, propane, propylene, normal butane, *iso*butane, butene-1, butene-2, *iso*butylene, normal pentane, *iso*pentane, several pentenes, normal hexane, normal heptane, normal octane, and several of the isomeric anes and enes of the C_6, C_7, and C_8, hydrocarbons. The list also includes such compounds as some of the acetylenes, butadiene, *iso*prene, benzene, toluene, and the three xylenes. Coöperative work is planned for the extension of the calibrations to other pure hyrocarbons. Fig. 4, and Tables 1, 2, and 3 illustrate some of the possibilities of the mass spectrometer.* Those analyses, which are labelled "manometer," refer to samples prepared from commercially pure hydrocarbons that were blended in known portions. The method of blending involved the use of a manometer.

*Analyses made by Consolidated Engineering Corporation, Pasadena, California (manufacturer of instrument).

Oil Industry Rubber Drive Nets $2,433,185

The American Red Cross, the Army Emergency Relief, the Navy Relief Society, and the United Service Organizations shared equally in a gift of $2,433,185.20, the proceeds of the Scrap Rubber Drive conducted last summer by the petroleum industry at the request of President Roosevelt.

Four checks, each for $608,296.30, were presented by William R. Boyd, Jr., chairman of the Petroleum Industry War Council, on behalf of America's petroleum industry to James F. Byrnes, Director of Economic Stabilization, official representative of the President, who gave them to the heads of the four service organizations. The occasion was a luncheon attended by members of the Council and a large number of prominent government officials.

The checks were received by Robert P. Patterson, Under Secretary of War, for the Army; Admiral Ernest J. King, Commander in Chief of the U. S. Fleet, for the Navy; Chairman Norman H. Davis for the Red Cross; and President Chester I. Barnard for the U. S. O.

The oil industry last summer reported to President Roosevelt a collection of 454,000 tons of scrap rubber during the drive, which the Council organized and directed nationally. The government's Rubber Reserve Company already has received and paid for 452,000 tons from the industry, according to Jesse Jones, Secretary of Commerce and chairman of Rubber Reserve Company. This national rubber stockpile has made possible Victory tires and the release of recap rubber without ration certificates for America's passenger cars.

The nation's oil companies paid a penny a pound for the rubber as they collected it, and they sold it to the Rubber Reserve at a cent and a quarter. The sum divided among the four relief agencies represented the difference between that penny a pound and the amount received from Rubber Reserve, so far accumulated by the Council in a trust fund. An additional sum will be distributed later when final reports are made.

No deductions of any kind were made for the out-of-pocket expenses of running the drive, which were estimated by Council Chairman Boyd to be several million dollars and much more than the amount presented to the relief organizations. This does not count the time spent by regular employees during the 26 days of the drive and since then in collecting, sorting, packing, and shipping the rubber, nor the use of regular facilities and equipment.

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Kerosine Has Extensive and Varied Field of Service

☆ Requisites of a good kerosine—
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PETROLEUM ENGINEER EXCLUSIVE Feature

by A. W. Trusty
Chief Chemist, Arkansas Fuel Oil Company

KEROSINE, formerly used solely as an illuminant, today has a wide and varied field of service. The use of kerosine as a heating agent is soon to exceed its consumption as an illuminant. A considerable quantity is used as fuel in internal-combustion engines. More and more industrial products such as insecticides, cut-back asphalts, paints, polishes, cleaning and degreasing compounds include kerosine as an ingredient. Contrary to the layman's first conclusion, the production of kerosine in the United States is steadily increasing. For example:

Year	*Percentage yield of kerosine from crude*	*Annual production (millions of barrels)*
1899	57.6	33
1904	48.3	57
1909	33.0	60
1914	24.1	63
1919	15.4	55
1924	9.3	57
1929	5.8	53
1935	5.8	55.8
1942	5.2	70

The demand for kerosine was the stimulus that initiated the search for petroleum and was the chief factor that determined the rapid growth of the industry.

In 1848 James Young of Glasgow made a kerosine from the distillation of a crude petroleum from a seepage in an old English coal mine. Later he made coal oil from cannel coal in Scotland on a commercial scale. By 1860 there were no less than 40 works on the American Atlantic Coast producing 7500 bbl. per year of coal oil from cannel coal imported from Great Britain. Within ten years of the discovery of Drake's well in Pennsylvania, the cannel coal works had shut down and 2,000,000 bbl. of crude oil per year were being produced.

The efforts of the early refiners was to realize the maximum yield of kerosine from the crude oil. The first commercial application of the cracking process probably was for the purpose of increasing the production of kerosine.

A. W. TRUSTY

graduated from Mississippi College in 1925 with a bachelor's degree—Joined staff of Lion Oil Refining Company as chemist and that same year (1925) transferred his affiliation to the Louisiana Oil Refining Company—In 1928 he became chief chemist of that company, which position he retained when later it became the Arkansas Fuel Oil Company—Resides in Shreveport, Louisiana.

It was customary to practice the "slow cooking" of the residuum after the normal yield of gasoline and kerosine had been removed in order to increase the kerosine yield. It is noted that a kerosine yield of 57 percent was realized from Pennsylvania crude by using such cracking technique and by the use of a wide boiling range on the kerosine.

The present relatively low yield of kerosine from the crude oil is due to several reasons. Naphthenic base crude oils do not contain such high kerosine contents as do paraffin crudes. The boiling range of kerosine has been narrowed considerably. For example, in the early days of refining the endpoint was usually 600°F. and higher and the first flash point specification was 73°F. minimum, compared with the present 115°F. minimum flash point specification.

Kerosine as Illuminating Oil

Archaeological explorations have revealed that the Egyptian and other ancient people used wick-fed lamps many thousands of years ago. Lamps have been made in a bewildering variety, often constructed from cans or bottles with a wick of string, vegetable pith, or rag. The various household lamps in general use also vary in type of wick, chimney, and supply of air to the wick. The construction of the lamp has considerable bearing on the burning quality of the oil; some kerosines burn well in one lamp and not so well in another type.

The three requisites for a good kerosine are:

1. It must give a flame of good initial candle power.
2. It must maintain this candle power as the oil burns.
3. It must not give rise to excessive deposits of film on the chimney.

Initial Candle Power

The size and brilliancy of the flame depend on the chemical composition of the kerosine and on the design of the lamp. Under ordinary conditions paraffin hydrocarbons will give the greatest flame height, naphthenic hydrocarbons less flame height, and aromatic hydrocarbons less flame height than any of the groups. The aromatics, however, give more luminosity for a comparative area of flame than do the paraffin. The luminosity is believed to be caused by the presence of carbon particles in the flame formed by cracking of the kerosine. The aromatics contain the highest percentage of carbon and the addition of aromatics to a paraffin stock will increase the unit luminosity, but decreases the total candle power. (See Table 1.)

The paraffin flame burns so much higher and larger than the aromatic oil that the increased size of the flame overcomes the greater intensity of the aromatic oil.

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The smoke-point apparatus used by the British Institute of Petroleum Technologists is perhaps the best means of quickly measuring the flame size.[1] (See Fig. 1.) To make the smoke point determination, put 10 cc. of the kerosine in the container. A piece of standard wick is soaked in the sample and fixed in the wick holder. The wick should project 3 mm. above the end of the wick holder. After the lamp has been burning for five minutes at a temperature of 68 to 77°F., with a 10 mm. flame height, the test is made by raising the wick until the flame smokes slightly, then reducing the height carefully until the smoky tail just disappears. The height of the flame at this point gives the value of the smoke-point test, in mm., read directly on the scale.

The tendency to smoke appears to be proportional to the aromatic and naphthene content. Kewley[2] blended a paraffin type kerosine with a sulphur dioxide extract from a highly aromatic kerosine:

Percent paraffin kerosine	*Percent aromatic extract*	*Smoke point*
100	0	32
95	5	29
90	10	26
85	15	22
80	20	20
70	30	14
60	40	10

In order to prove that the naphthenes had low smoke points, the following test was made. The kerosine from a naphthene base crude oil was sulphonated to remove the aromatics. This kerosine was compared with a sulphonated paraffin base oil.

	Sulphonated paraffin kerosine	*Sulphonated naphthenic kerosine*
°A.P.I. gravity	51.3	37.4
Boiling range	338-518°F.	339-518°F.
Smoke point	32	20

In addition to giving an indication of the maximum size of flame at which the kerosine can be burned without smoking, and thus the initial candle power, the smoke-point test gives an indication of the ability of the kerosine to burn in a draughty atmosphere without smoking. As a sudden draught will extend the flame of a kerosine, the higher the smoke point the less tendency there will be for the flame to reach its maximum height and to begin smoking.

[1]*The Science of Petroleum, Oxford Press*, p. 2477.
[2]Kewley, J., *J. Inst. Petr. Tech.*, 13, 371 (1927).

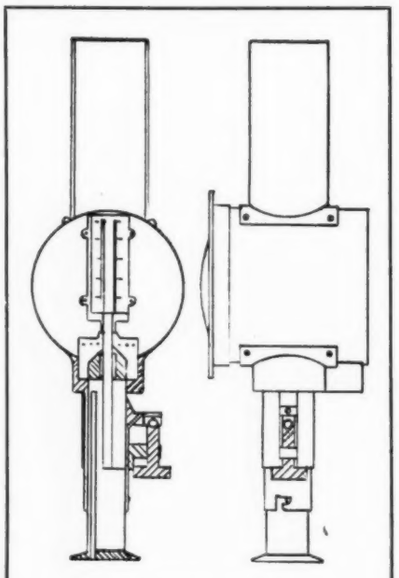

Fig. 1. Smoke point lamp

Lamp Design

The lamp design has a marked bearing on the burning quality of the kerosine. In the case of a lamp of a very primitive type, such as are used in the Far East, the best grades of kerosine burn badly and the inferior grades nearly as well as the best grade. The method of introducing the air (location of air holes), the type and height of the wick, and type of burner affect the burning of the oil. In general, it may be said that in lamps with a poor draught kerosines composed mainly of paraffins burn well, whereas those rich in naphthenes, and especially aromatics, burn with a reddish and even smoky flame. In a well-designed lamp with a good draught, the aromatic type of kerosine will burn brilliantly, whereas in the same lamp the paraffin kerosine will burn with a flame of weak luminosity.

TABLE I

	°A.P.I. gravity	*Candle power*	*Candle power per sq. cm. of flame*
Pennsylvania paraffin base kerosine	50.6	14.2	0.591
Pennsylvania + 2.5 percent tetralin	49.7	15.2	0.630
Pennsylvania + 5.0 percent tetralin	48.5	14.7	0.641
Pennsylvania + 7.5 percent tetralin	46.9	14.1	0.650
Pennsylvania + 15 percent tetralin	43.6	13.6	0.680
Pennsylvania + 20 percent tetralin	41.5	12.4	0.720
Pennsylvania + 30 percent tetralin	36.8	10.3	0.766
Pennsylvania + 40 percent tetralin	33.4	5.2	0.766
100 percent tetralin	17.5	5.2	0.950

Candle Power Maintenance

The two factors affecting the maintenance of a good flame are:

1. A constant supply of kerosine to the wick.
2. Complete combustion of the oil without char formation on the wick.

A constant supply of oil to the wick depends on the distance between the oil level and the top of the wick, and on the viscosity of the kerosine. Nakamura[3] used two lamps, one with a distance of one inch between the oil level and the top of the wick, another with a difference of nine inches. The consumption of oil in the shallow lamp was greater and the candle power remained more constant during the test.

Time, hours	*Shallow Reservoir (candle power)*	*Deep Reservoir (candle power)*
0	20.0	20.0
1	20.6	13.8
4	21.8	12.0
8	21.8	11.0
12	21.8	10.2
15	Oil consumed	2.6

Viscosity

If the viscosity is not correct to insure an ample supply of kerosine to the wick as the level in the reservoir falls, the flame size decreases. If the decrease in flame height is corrected by turning up the wick, the rise in candle power is only temporary. As soon as the surplus kerosine so obtained burns off, the then over-protruding wick carbonizes, adding a further trouble to that of the decreasing illuminating power. A kerosine that burns with a large flame in a certain lamp will require a lower viscosity than one that burns with a low flame. It has been suggested that the viscosity of a kerosine should not exceed 2.0 centipoises at the temperature at which it is to be used.

Kerosines of paraffin base show less change in viscosity with change in temperature than do kerosines of naphthene base.

Char Formation on Wick

The "char" on the lamp wick may be hard and brittle or it may be soft and powdery. It may occur in irregular localized deposits as "mushrooms," which produce distortion of the flame and lead to smoking. Or, the char may be a uniform deposit that encloses the surface of the wick, restricts the size of the flame, and eventually leads to its extinction.

A quantitative estimate of the extent of char formation may be made as follows: Take the wick from a lamp that has completed the 24 hours A.S.T.M. burning test and cut off the top 3 cm. Remove the char from the wet wick as completely as possible with a spatula.

[3]Nakamura, *J.S.C.I.*, 2, 535 (1883).

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The inclusion of some partially burned fibers is unavoidable in removing the char from the wick. This is not serious as, after the char has been dried to a constant weight in an oven at 230°F., the wick fibers can be carefully picked out with forceps. The weight of char is reported in mg. per liter of kerosine burned.

The design of the burner and the composition of the kerosine are the two factors affecting the char formation. The same kerosine when burned in two lamps of different design may give varying char formation, which is proof that the burner design is a variable factor. Wicks with a high ash content have been found to give more char than wicks with lower ash contents.

Kerosines having an aromatic content, which have a tendency to smoke, give heavy incrustation, but the char is softer and more amorphous than is the char from a more paraffin kerosine.

The heavier fractions of the kerosine tend to give more formation than do the lower-boiling fractions. The presence of refining by-products increase the char formation. For example, a kerosine treated with sulphuric acid at a temperature of 60°F. gave less char than the same kerosine treated at a temperature of 90°F. The presence of unsaturated bodies are responsible for char formation.

The char formation is of particular importance in kerosine used in lamps in incubators and brooders where the lamps are required to burn for a long time with the minimum of attention. For this service, a constant flame size is of great importance. Excessive char formation will reduce the size of the flame, and may eventually extinguish the flame. In the case of brooder lamps it is also important that the oil should not emit fumes of a sulphurous nature.

Chimney Deposits

The formation of films on the chimney depends not only on the hydrocarbon composition but also on the impurities, such as sulphur compounds.

A brownish deposit indicates incomplete combustion with the production of smoke, and may be due to the formation of excessive char or to burning of the kerosine in a drafty place. In the latter case a kerosine of higher smoke point should be used.

A bloom of white, grey, or blue color is due primarily to the effect of the sulphur content. The formation also depends on other factors: the temperature of the lamp chimney, the draft, and the purity of the atmosphere. It has been found that new lamp chimneys give more bloom than do those that have been used and cleaned several times. The alkali in the chimney itself apparently is the cause of the phenomenon. The presence of ammonia in the atmosphere increases the bloom considerably. Fog, particularly the smoky variety, has a similar effect. The film on the chimney may contain sodium sulphate, ammonium sulphate, and organic acidic bodies from the oxidation of the sulphur compounds in the kerosine.

The formation of bloom is affected by the design of the lamp chimney. The bulging type that keeps relatively cool is particularly prone to this trouble, whereas the long, narrow type, which is relatively much hotter, shows much less bloom formation. A chimney that widens suddenly near the top (crimp top type) gives a less steady and powerful draft than a chimney that has straight sides or narrows evenly from the bulge. In the latter type of chimney a flame is, therefore, less likely to flicker.

Color Stability

The cause of the deterioration of the color of kerosine has been the subject of much work in recent years. There appear to be several different types of such instability:

1. A clear lemon-yellow type, very erratic in its development, the most common in refined kerosines. It is an oxidation effect not apparently limited to any definite set of compounds, it develops in the dark and is almost entirely bleached by exposure to sunlight. Hillman[4] found that treatment of a kerosine with lead peroxide in caustic soda produced a discoloration of the same type. Various samples that had gone off color by long storage in the dark behaved on exposure to the sunlight in precisely the same way as the samples artificially oxidized to the same color.

The presence of small quantities of phenols, or hydroxyl compounds, and possibly nitrogen bases has been suggested as the cause for this type of discoloration. A slight alkalinity and contact with metals, especially copper, also accelerates the color drop.

2. A second type of discoloration is similar to the first and is attributed to the presence of amino bodies. It may or may not be sensitive to the light.

3. A third type is due to unsaturated bodies, which form polymerization products and which cannot be bleached in the sunlight.

A number of oxidation inhibitors have been suggested to prevent kerosine discoloration. These include hydroquinone, pyrogallol, resorcinol, urea, thiourea, dihydroxy benzenes, ethanolamines, etc.

Fig. 2. A.S.T.M. test lamp

Color Stability Tests

A number of color stability tests have been used by the various companies to predict the stability of kerosine during shipment and storage in foreign countries.

The method used by a major company in California is as follows:

Reagent—Dissolve 300 g. potassium ferricyanide in one liter of water. Dissolve 100 g. sodium hydroxide in one liter of water. Mix equal volumes of these solutions to form the alkaline ferricyanide reagent.

Procedure—Into a clear 8-oz. sample bottle, place 125 ml. of oil and 15 ml. of the ferricyanide reagent. Shake vigorously for 60 seconds and allow to settle for 60 seconds. Filter and read the color on the Saybolt colorimeter.

Color below 0	Inferior stability
0-9	Poor stability
10-15	Fair stability
16-20	Good stability
Above 20	Superior stability

The method used by another company is as follows:

Add 0.04 ml. of a copper palmitate catalyst solution to 100 ml. of the kerosine in a 4-oz. Pyrex bottle. After thorough shaking, the bottle is stoppered loosely, put into an electric oven and held at 158°F. for a period of 16 hours. After the oven period, the kerosine is allowed to cool in the dark, and the Saybolt color taken.

(Continued on Page 125)

[4]Hillman, E. S., *Proc. World Petroleum Cong.* 2, 708 (1933).

(Continued from Page 122)

The Saybolt color scale is not proportional throughout the entire range to the actual concentration of tinctorial material present. Therefore, an absolute scale is used in order to compare the color stability on the basis of the actual amount of tinctorial material formed under the condition of the test.

Saybolt	Absolute scale
30	0.50
29	0.56
28	0.62
27	0.71
26	0.83
25	1.00
24	1.11
23	1.25
22	1.43
21	1.66
20	1.86
19	2.11
18	2.42
17	2.76
16	3.20
15	3.80
14	4.40
13	4.80
12	5.20
10	5.50
8	6.20
6	6.70
4	7.3
2	8.0
0	8.9

Example: A color drop of from 24 to 16 is: 3.20—1.11 = 2.09 on the absolute scale.

Interpretation: On the absolute scale the color stability classification is as follows:

Color loss, abs. scale	Rating
0-1	Good
1.01-2	Fair
2.01-3	Doubtful
3.01-4	Poor
Above 4	Very poor

Lead Peroxide Test

To make the lead peroxide stability test one gram of lead peroxide is dispersed in 20 ml. of 0.175 normal caustic soda solution. The mixture is added to 700 ml. of the kerosine to be tested at a temperature of 86°F. and the mixture thoroughly stirred for 60 seconds. After five minutes of settling, the kerosine is tested for color drop. Hillman[4] states that a kerosine that develops a color drop by this test will be very likely to go off color in storage.

Specifications

The Federal specifications for kerosine supplied to various branches of the U. S. Government are as follows (VV-K-211A, 1941):

Flash point	115°F. min.
Endpoint	572°F. max.
Sulphur	.13 percent max.
Color, Saybolt	16 min.
Burning test	24 hours*

*At the end of the burning test, the flame shall not be smoky and shall be practically as large as when the final adjustment of the wick was made, the chimney shall be clear or only slightly clouded, and no appreciable hard incrustation shall be on the wick.

Burning Quality Test

Method of test for the burning quality of kerosine oil (A.S.T.M. D187-39): The lamp (see Fig. 2) is cleaned and 850 ml. of the kerosine is poured into the font. The wick is trimmed with scissors so as to produce a flame measuring 1¾ in. in height and 1¾ in. in width at its widest point. The lamp is allowed to burn continuously without any flame adjustment for a 24-hour period. The lamp is refilled to within ¼ in. of the top of the font at intervals of 8 hours without putting out the flame. At the end of the 24-hour period, the height and width of the flame is measured. The condition of the chimney is reported as light, medium, or heavy deposit of a white, yellow, or brown color. The condition of the wick regarding crust, "toadstools" and condition of fiber is reported.

Burning quality of long-time burning oil (A.S.T.M. D219-36). The lamp is cleaned and 750 ml. of the oil poured into the font. The wick is trimmed, lighted, and adjusted to give a flame height of ¾ in. At the end of 96 hours and at 120 hours the lamp is weighed, and the average rate of oil consumption per hour calculated for the 96- to 120-hour period. The time required to burn 650 ml. of oil is calculated and the lamp is burned for this period of time. At the end of the test the change in height of the flame and condition of the wick and chimney are observed and reported.

Blue Flame Appliances

Blue flame burners are usually designed in such a manner that the flame burns in the annular space between two concentric cylinders both perforated with numerous holes. The design, dimensions, and arrangements of these holes are so correlated with the factors determining the draft that a blue hot flame is obtainable. Such burners give complete combustion so that if kept clean there is very little odor. Many such stoves or heaters are fitted with a constant level feed so that the flame will not decrease in height with a drop in level in the reservoir. Certain cookers of this class are fitted with short asbestos wicks dipping into an annular reservoir supplied from the constant feed, arrangements being made for regulating the height of the flame.

Suitable kerosine for a blue flame burner should not form excessive char and should not give off objectionable odors.

Vaporizing Appliances

Lamps, heating stoves, and cookers employing the principle of vaporizing the kerosine and burning the air-vapor mixture have been developed, and many successful types of such appliances are now available. The kerosine is vaporized by passing through a highly heated vaporizing tube under pressure. The pressure must be sufficient to give the stream of kerosine vapor, issuing from a fine orifice at the end of the vaporizer, the necessary velocity to draw into the mixing tube sufficient air to form a gas that, when burning with the secondary supply of air available around the flame, results in a non-luminous flame.

The temperature of the vaporizing tube of such stoves is about 840°F. At this temperature, with the short time that the kerosine is exposed to the heat, cracking does not take place to any extent, and little trouble has been encountered with clogging of the vaporizing tubes. A wide range of kerosines seem to be suitable for this type of burner.

Power Kerosine

used as fuel for tractors and other spark ignition engines. Recent changes in design of some tractor engines has made it desirable to blend or substitute cracked naphthas for the purpose of raising the anti-knock value of the fuel. The desirable properties of a power kerosine are: (1) ease of vaporization, (2) high anti-knock value, (3) and low crankcase dilution tendency.

Other Uses

Most domestic insecticides contain a proportion of kerosine, the main characteristic of which is freedom from odor. The kerosine should have a high flash point to reduce the fire risk, and a low final boiling point in order to insure rapid evaporation. Other industrial uses are as ingredients in paints, polishes, cleaning and degreasing compounds, and cut-back asphalts.

——☆ ☆ ☆——

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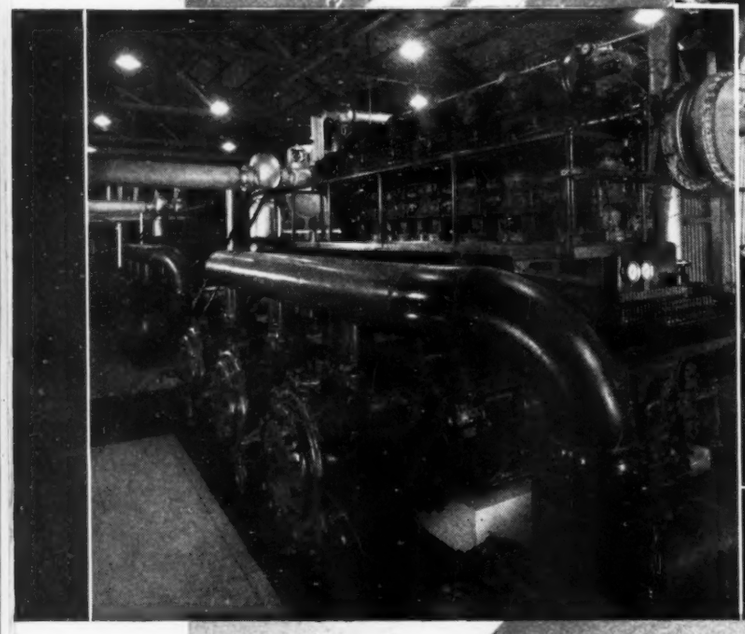

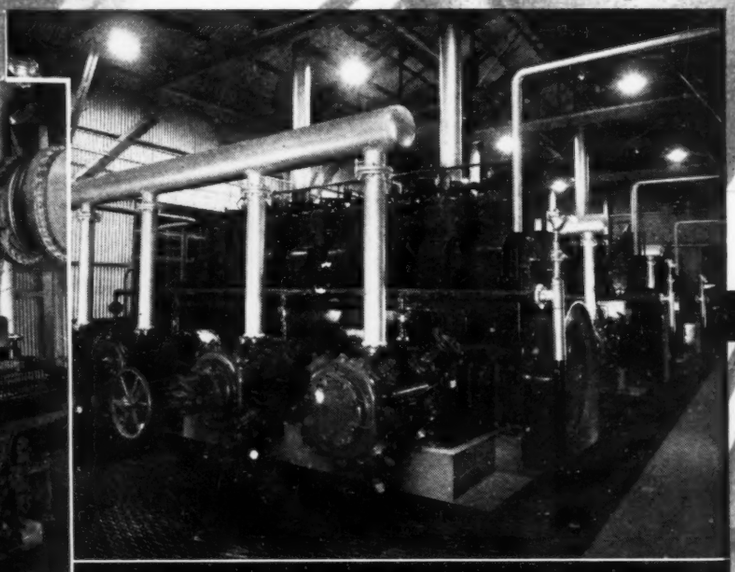

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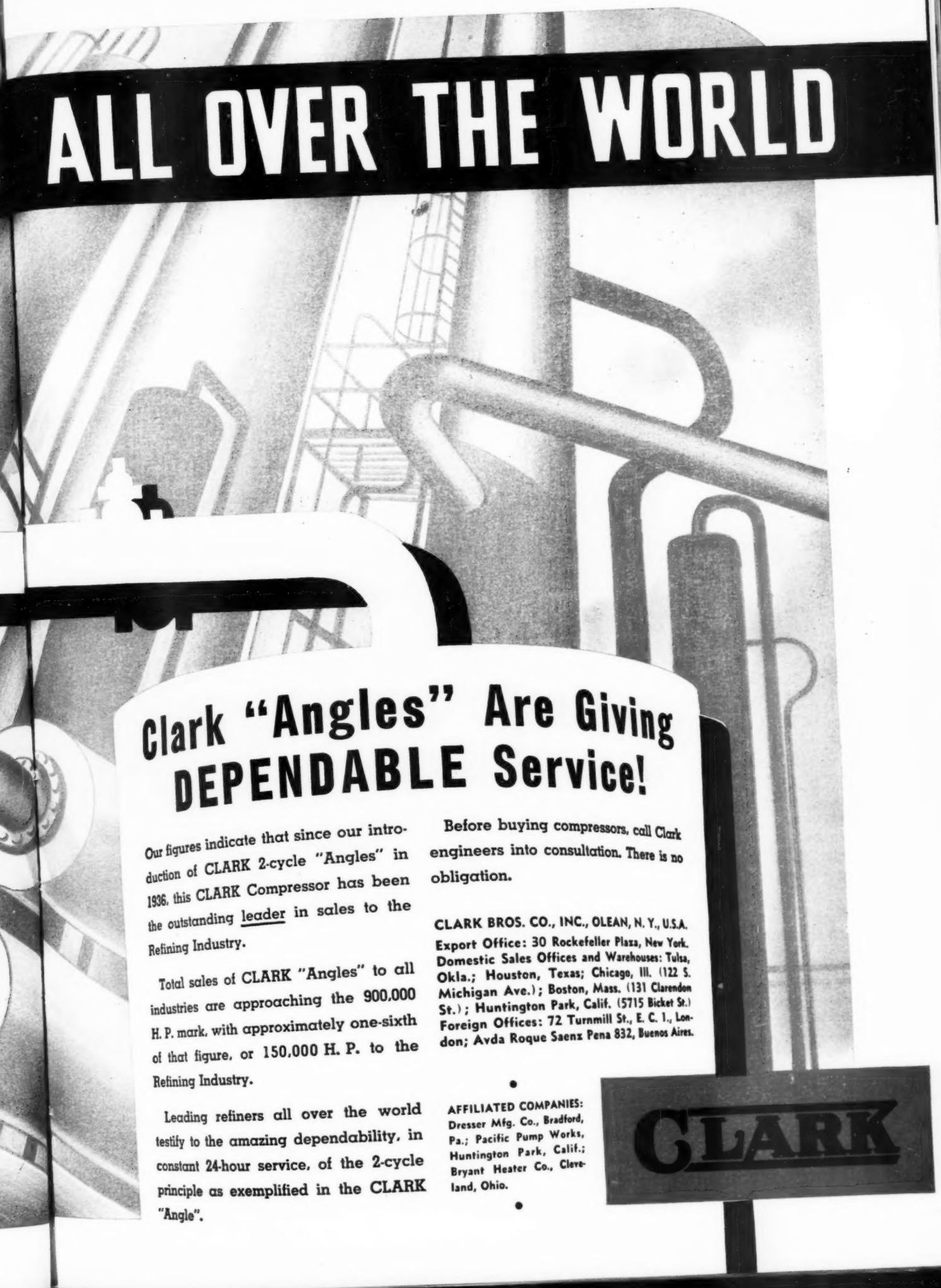

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Testing Elasticity of Synthetic Rubbers at Low Temperatures

PETROLEUM ENGINEER EXCLUSIVE Feature

☆ Manufacture of many new synthetic rubber compounds results in need for efficient testing methods

by George D. Kish

Development Engineer, Dresser Manufacturing Company

WITH the appearance of many new synthetic rubber compounds the need arose for quick and practicable testing of these materials, to determine their comparative applicability for uses formerly filled by natural rubber compounds. One of the most important points to be determined in regard to these synthetic rubber compounds was their elastic behavior at low temperatures. In many applications such information was of an imperative nature when these synthetics were to be introduced into the design of a new product. To obtain data on the elasticity of synthetic rubbers at low temperatures, accurately, the company with which the writer is associated devised an instrument called an "Elastensometer."

Dresser coupling gaskets, compounded with natural rubber have made possible pressure-tight joints in gas, water, and oil pipe lines for as long as 60 years without replacement. This type of coupling utilizes wedge-section gaskets as illustrated in Fig. 1. The flexing of these rubber-section gaskets permits, in the coupling, a movement of the pipe caused by temperature changes, soil settlement, and other disturbances, yet maintains a perfect seal and connection. The investigation of various synthetic compounds for use as coupling gaskets during the present emergency therefore, presented serious testing problems, in order to assure the maintenance of high quality and long life in service.

GEORGE D. KISH

graduated from Allegheny College, Meadville, Pennsylvania—A native of the Bradford oil-producing country, he has had extensive experience in manufacturing and field developmental work connected with the oil and gas industry—Kish has been instrumental in developing many of Dresser's new products as well as converting peacetime products to war use.

A compound that has the satisfactory physical characteristics required for gasket material must retain those qualities under extreme conditions of temperature, in order to be acceptable. It has been found, for example, that some synthetic compounds, although exhibiting satisfactory characteristics in other respects, will become brittle as glass at temperatures somewhat below the freezing point of water.

The many new synthetic rubber compounds have to be carefully tested to determine those best suited for the individual application. The Elastensometer, by use of which the "freeze resistance" of these synthetics can be determined, has been successful in filling the need for such data. The principle of this instrument is illustrated diagrammatically in Fig. 2. Utilization is made of the fact that, for rubber-like materials in general, the modulus of elasticity varies inversely with the elongation, as the temperature is lowered. A sample of the material to be tested is supported in the form of a simple beam (B), 0.290 in. dia. by 1½ in. long, free supported over anvils (AA) and centrally loaded at (H). The force (F) required to produce a given constant deflection (D) is transmitted through spring (T) and indicated on scale (P). Knowing the value of (F) at intervals of temperature, as the temperature of the test bar is dropped, a force-temperature curve can be plotted. The critical limit of normal elastic properties is reached at such temperature where the force required to produce constant deflection increases rapidly.

Fig. 3 is a photograph of the Elastensometer as constructed. A dial indicator is direct-connected to the loading rod and shows the deflection in thousandths of an inch. Loading is applied with a hand-lever and is transmitted to the test bar through a double-wound spring. Calibration of the loading spring, Fig. 4, for values indicated on the vertical scale was made directly by unscrewing the anvil plate and mounting the instrument on a pipe fixture over the platform of a weighing scale. A suitably encased thermometer is mounted close-grouped with the deflec-

(Continued on Page 132)

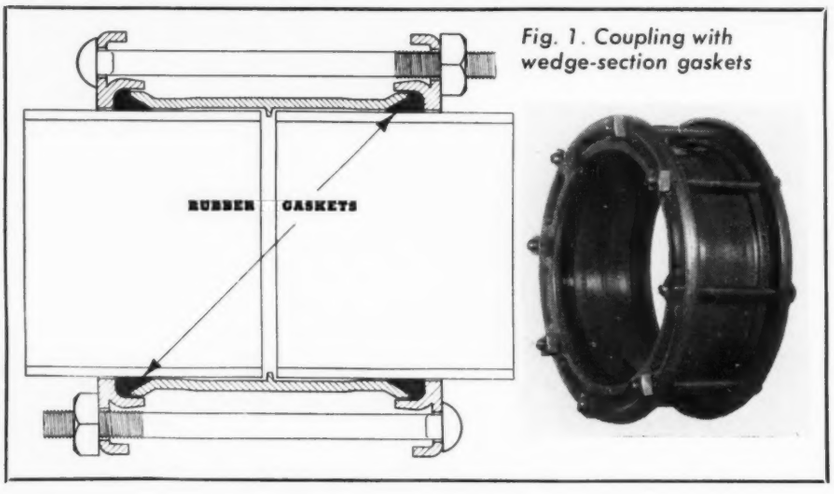
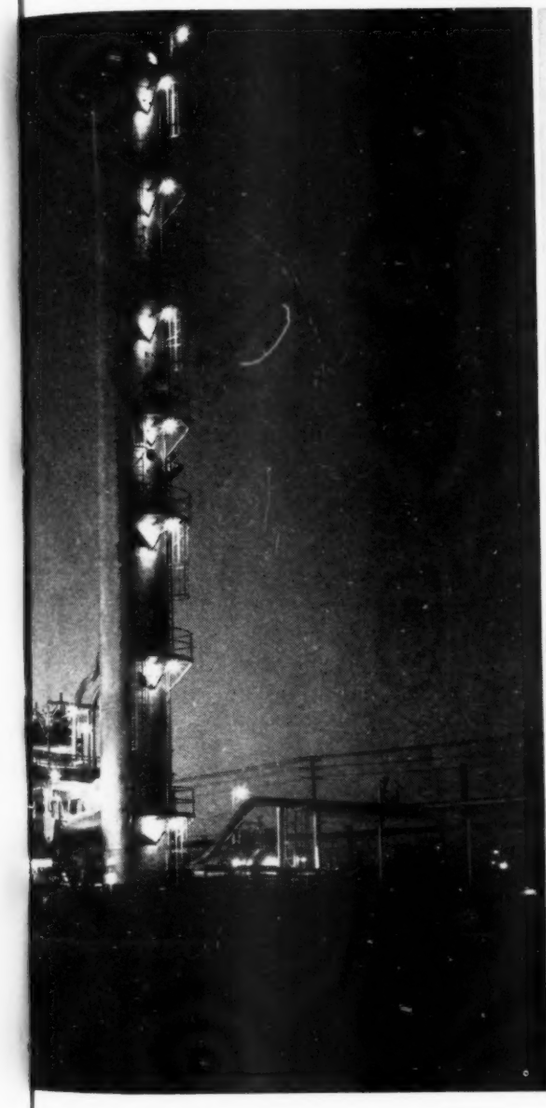
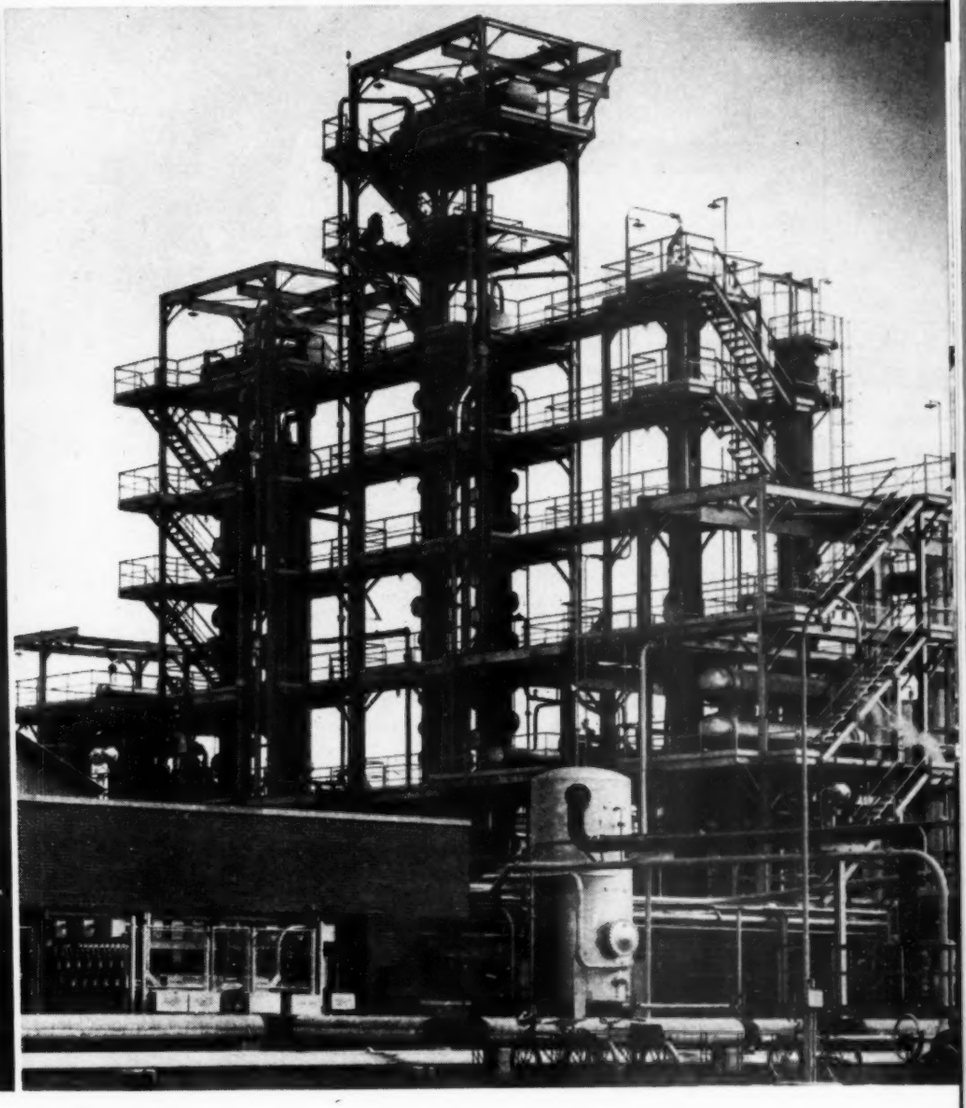


Fig. 1. Coupling with wedge-section gaskets

tempo of each new day

BY EXTREME FLEXIBILITY OF *UTILITY ELECTRIC POWER* . . .





The remarkable advancement in the field of refining is one of the amazing achievements of the day. High-quality aviation-fuel ingredients, high octane gasolines, Butadiene for synthetic rubber, and many other developments directly vital to Victory can be attributed to refining progress. In other words, the refining industry has made itself *flexible*. It is geared to the tempo of each new day. Likewise, Utility Electric Power is also extremely *flexible*. It is designed to meet the ever-changing need for power, wherever and whenever that need arises. Yes, *Utility Electric Power* has gone to war "behind the lines." . . .

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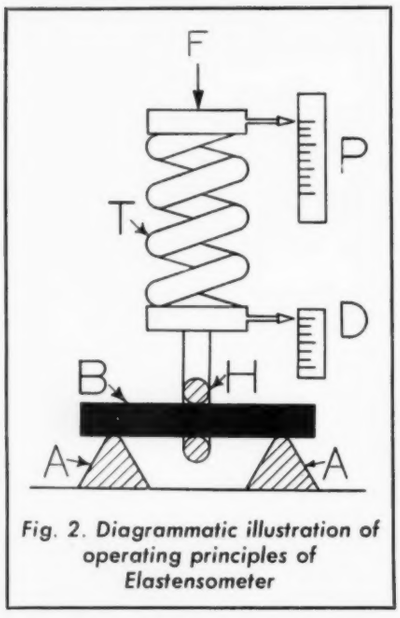

Fig. 2. Diagrammatic illustration of operating principles of Elastensometer

(Continued from Page 128)

tion dial and force scale for easy reading of all three. The instrument weighs less than 5 lb. and was designed to be supported in the left hand while being operated with the right.

A lay-out of the complete equipment required for testing is illustrated in Fig. 5. This includes the Elastensometer, insulated cup splash-pan, cracked dry-ice, alcohol, a hollow cutter for making 0.290 in. dia. by 1½ in. long test-specimens, spoon for handling the dry-ice, and tongs for inserting the test-specimen into the anvils.

Making a Test

To conduct a test, the sample is inserted into the anvil, Fig. 6, and through the looped end of the loading rod; as 1 in. of the 1½ in. length is unsupported, ¼ in. of support is obtained on each anvil and the test bar is prevented from slipping out by means of removable pins. Testing is begun with the base of the instrument immersed in a cup of alcohol at room temperature. The technique of the test is to apply a sufficient load with the hand lever to produce a given deflection; the indicated force and temperature are then noted and the load is allowed to return to zero. This process is repeated at suitable intervals as the temperature is carefully lowered by the addition of small quantities of dry-ice to the alcohol until the desired low temperature is obtained. Stirring is accomplished as required by raising and lowering the instrument thus allowing the coolant to flow through holes in the base plate.

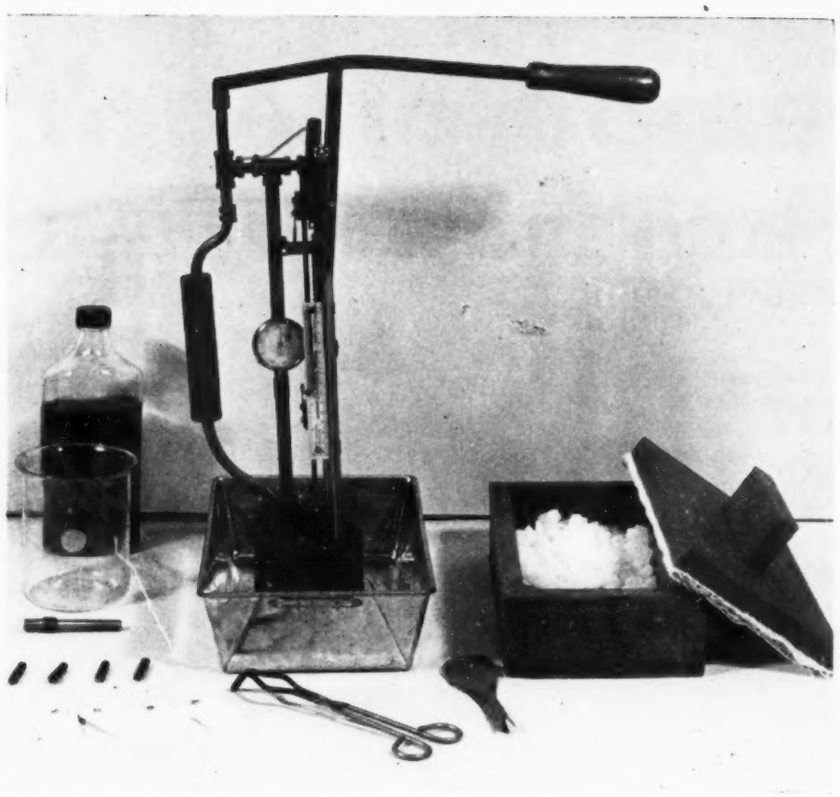

Fig. 5. Complete layout of testing equipment: Elastensometer, insulated cup, splash pan, box of cracked dry-ice, alcohol, beaker, hollow cutter, test specimens, forceps, and spoon

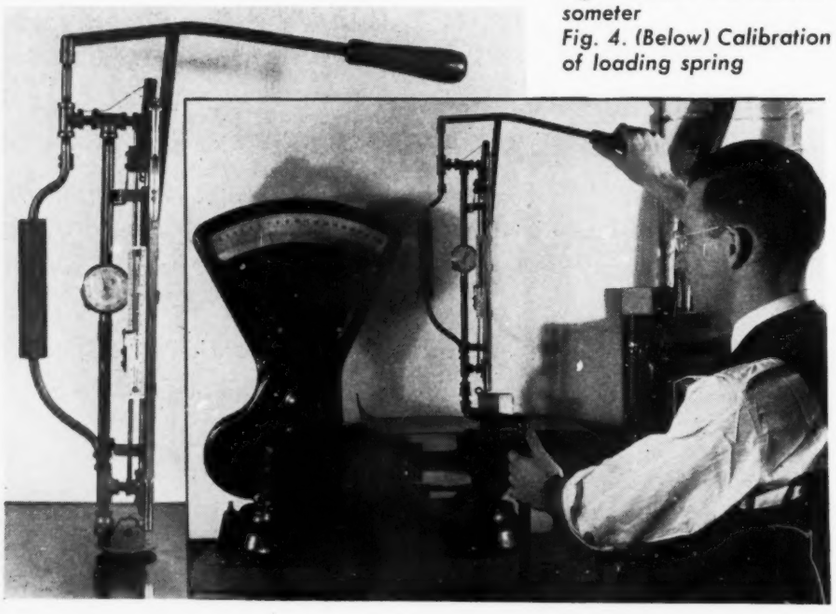

Fig. 3. (Left) The Elastensometer
Fig. 4. (Below) Calibration of loading spring

The Elastensometer was designed to provide economy of time and material and ease of operation. First consideration in this respect was to achieve simplicity in preparation of the test-specimen. This was accomplished by cutting the specimen with a hollow cutter operated in a drill press, Fig. 7. By this method, uniform, cylindrical pieces 0.290 in. dia. by 1½ in. long can be produced from any part of a plaque of the compound to be tested. The anvils (AA), Fig. 2, are placed to give free support at a distance of 1 in. apart; this helps to simplify calculations. If desired, a numerical value for the modulus of elasticity in bending can be determined for any temperature, as testing can be conducted even when the material is in a brittle state. (Tests at high temperatures can be conducted by use

(Continued on Page 136)

July 15th

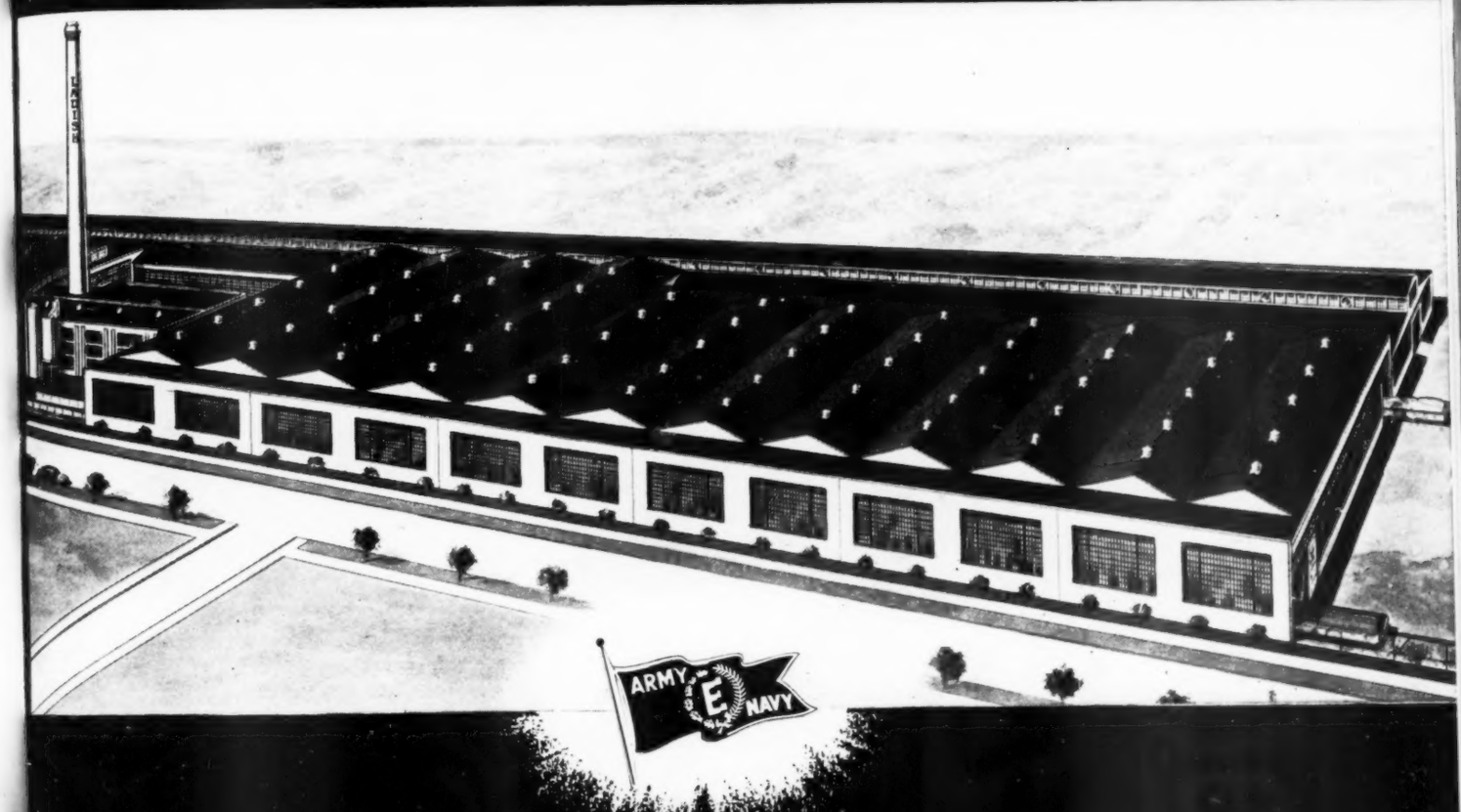

Fig. 6. Inserting a test specimen into the supporting anvils of the Elastensometer

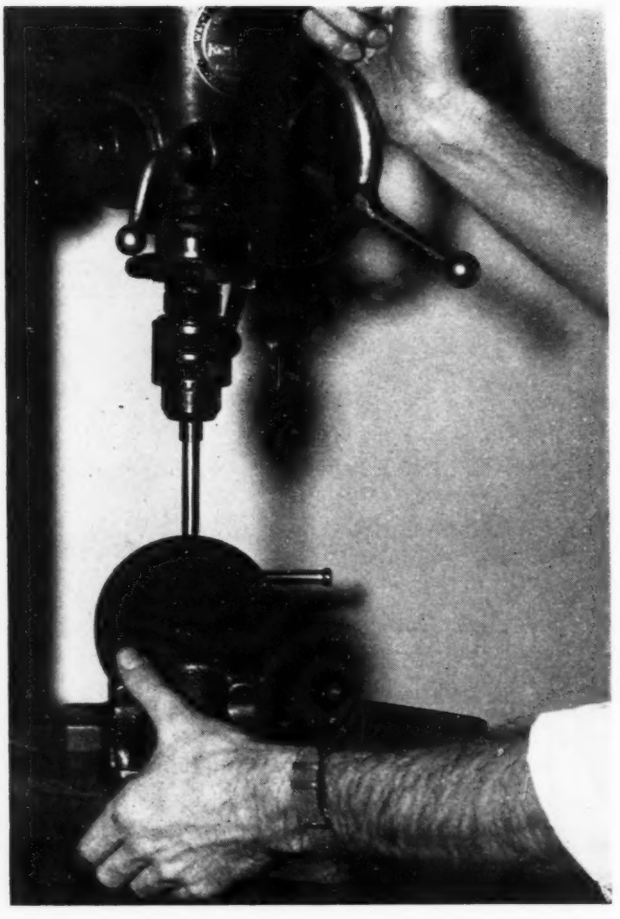

Fig. 7. Cutting a test specimen with a hollow cutter in a drill press

(Continued from Page 132)

of a heated cup with or without an immersion fluid.) The operational base of the device, together with the test-specimen, is compact enough to permit immersion in an insulated cup of only 300 cc. capacity. Further advantage of the method lies in the fact that comparatively small testing forces are required, as opposed to tensile pulling, which makes for a light, easily handled and hand-operated instrument.

Test Results

Figs. 8 and 9 represent test results of two different compounds of like characteristics at room temperature, but widely differing at low temperatures. In each case two curves are represented, showing effect of different values chosen for deflection (D). To provide quickly made comparative results the same deflection must, of course, be applied to all tests. Points (X, X^1) on the curves indicate the critical limit as determined by inspection. The critical limit as referred to in this reference is defined as that temperature at which the modulus of elasticity begins to increase at a rapid rate. By plotting values of force required to produce a constant deflection against temperature, the first sudden change of curvature indicates the critical limit.

Factors affecting the choice of deflection (D) are:

1. The maximum value that will not cause a permanent set at the testing temperatures, remembering that the modulus of elasticity tends to increase as the temperature is lowered.

2. The minimum value that will show marked change of curvature at the critical values of temperature. If (D) is too small, significant points on the curve may escape visual detection.

In general, the maximum value of (D) that will not cause a permanent set, i.e., exhibit negligible time-lag in achieving full recovery, is used. D = 0.050 in. has been found to be of ample range for almost all commercial synthetic rubbers produced thus far where the critical limit is of chief interest. For studies considerably below the critical limit a smaller value, as for example, D = 0.030 in., is used.

A descriptive scale of interpretation may be applied to the D = 0.050 in. curve as follows:

0 to 8 lb.—flexible
8 to 15 lb.—semi-flexible
15 to 22 lb.—firm
22 to 30 lb.—hard
30 to 40 lb.—brittle

Descriptive scales of elastic behavior for other values of (D) below the critical limit are, in general, chiefly dependent on the nature of the application. When the material is almost completely confined, as is the case with Dresser coupling gaskets, the "semi-flexible" state is in the safe zone. For such applications as automobile tires, for example, where there is no confinement and the material is directly exposed to wear, the critical limit would probably define the safe temperature limit, and might require closer definition.

The modulus of elasticity (E), in bending, at any temperature may be obtained by the use of the conventional beam deflection formula:

$$E = \frac{P L^3}{48 I D} \quad \text{. . equation (1)}$$

Where:
P = load in lb. (applied gradually),
L = length (= 1 in.),

(Continued on Page 140)

Simplified

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(Continued from Page 136)

I = moment of inertia of cross-section about the neutral axis ($= 0.04909\ d^4$), and

D = deflection in inches.

As the modulus of elasticity in bending (E) tends to increase as the temperature is lowered, Fig. 10, the limiting critical temperature as obtained with the Elastensometer may be closely defined as that temperature at which the normal value for (E) increases to the maximum value permitted for the application. For materials exhibiting given elastic characteristics at normal temperatures, the tolerable deviation at the limiting temperature may be specified in percentage of increase in (E). For example, rewriting equation (1):

$$E = K\frac{P}{D} \quad . \ . \ . \quad \text{equation (2)}$$

Where:

$$K = \frac{L^3}{48\,I} \quad . \ . \quad \text{equation (3)}$$

Using the values plotted in Fig. 8 for a test-specimen whose diameter is 0.290 in.:

$$K = \frac{1}{48 \times 0.04909 \times 0.290^4} = 60$$

. . . . . equation (4)

A table of values may then be constructed as follows:

Temperature, °F.	*E*	*Percent increase of E*
+20		
60 (taken as normal)	6000	0
—20	7200	20
—37	8400	40
—40	9600	60 (typical critical limit selected by visual inspection: points X, X¹ Fig. 8)
—45	12000	100
—57	24000	300
—68	36000	500
—85	48000	700

Although the critical limit may thus be specified mathematically, determination by visual inspection is usually adequate. Good results may be obtained with comparatively large tolerances on the diameter of the test-specimen.

Tests made with the Elastensometer have been found convenient and inexpensive to conduct, as no great outlay of equipment is required. As many as 3 to 5 tests have been made per pound of dry-ice. A sample compound can usually be tested in 15 minutes, including the time required for cutting the test-specimen in a drill press.

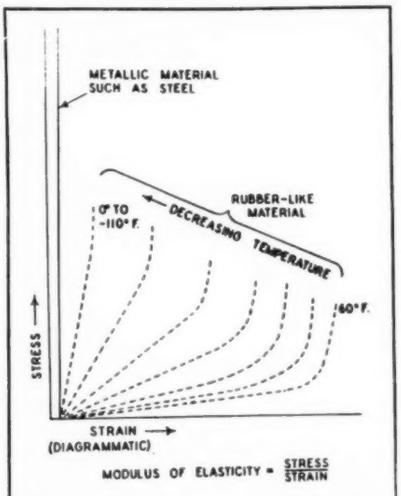

Fig. 10. Diagrammatic illustration of the changing values of E (modulus of elasticity) of rubber-like material with decreasing temperature

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Fig. 8. Test results of a typical safe low-temperature material

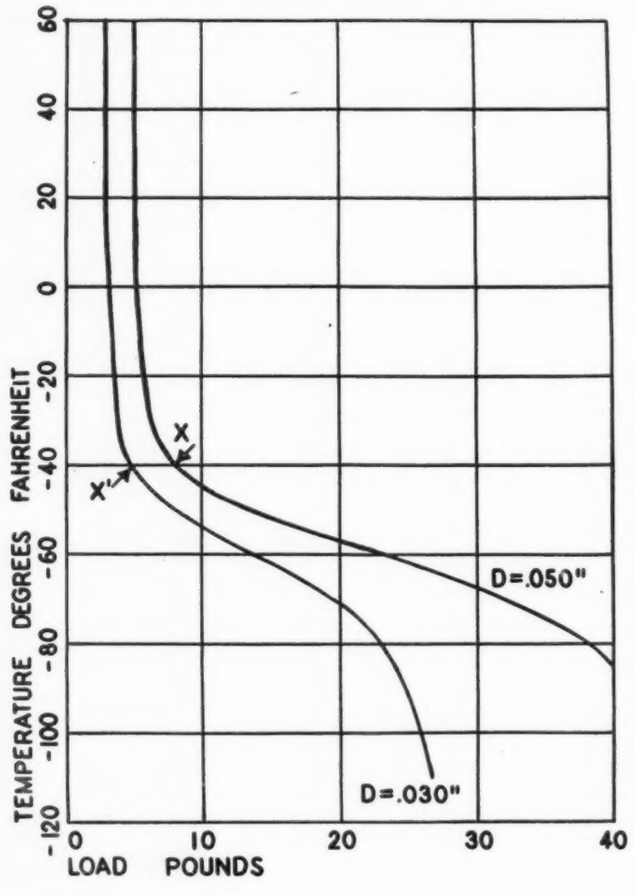
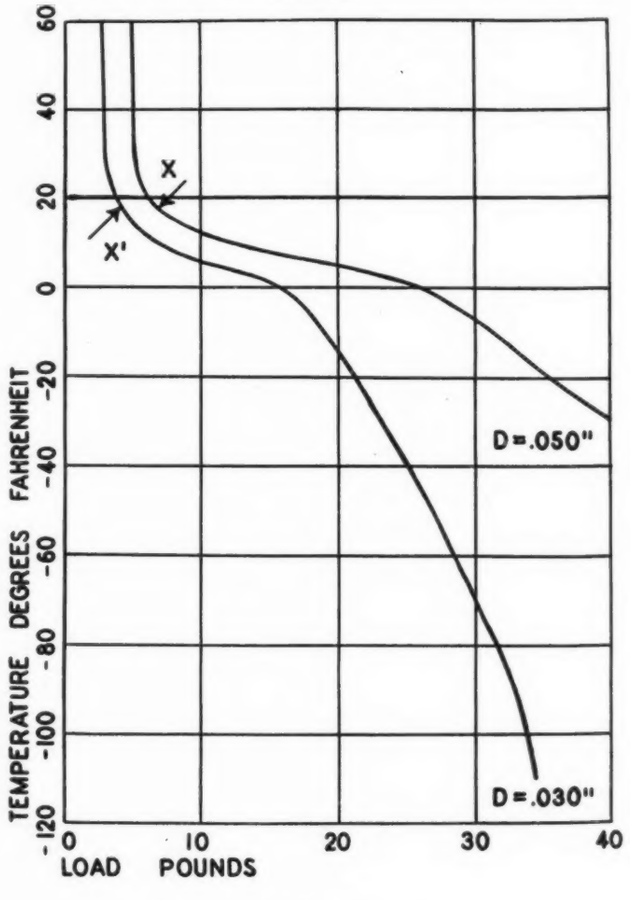


Fig. 9. Test results of another typical safe low-temperature material



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Class Meeting No. 8 (Continued)

NOTE: Throughout the class proceedings, no attempt is made to distinguish the identity of the pupil speaking. When a series of remarks is made by pupils it usually denotes an interchange of discussion among the class members themselves.

EDITOR'S NOTE: At the end of last month's installment the point was made that n-paraffins are crude scale waxes and *iso*paraffins are amorphous waxes.

Pupil: That points out the possibility of separating out by removing from the wax the 1, 2, and 3 naphthenic rings in the wax with balanced side chains and if you could unbalance those chains without completely wrecking the molecule, you would have a valuable lube.

Pupil: I had the privilege of hearing Rossini speak on this particular research project at Kansas State College. We were all taught in our elementary organic chemistry courses that the number of hydrocarbons present in petroleum crudes ran into the millions, counting isomers, a number arrived at by arithmetical operations on the number of carbon atoms in the heaviest molecules. Rossini stressed the fact that this research project indicated that the molecular types present in crude oil are limited to a few thousand rather than millions and that certain of these appear to have dominant characteristics. We might take this to indicate that chemical operations on a few molecules might be effective in altering the characteristics of a product. At that time Rossini had done only a little work on the heavier fractions. It might be interesting to the group to remark that the equipment used in the distillations was a packed tower of more than 100 theoretical plates and run at a reflux ratio of more than 500. The heavier ends were treated with various solvents and separated by solubility and freezing point differences.

Pupil: What is the viscosity index number on those?

Pupil: I don't have any information on that. I suspect it is higher than the fraction in the water white oil. That is why I mentioned there is a possibility of blending back.

Pupil: At the time this article was written, the wax portion was turned back and had not been worked on much at that time.

Leader: Perhaps the symmetrical molecule idea might give us some concept as to why cracking will make a more definite wax crystal. Anybody else have any questions? We will get to the matter of economics. I want to say that until very recently I didn't have enough data to get a very good picture in my mind and I found that one of our class members already had considerable data. Will you give your findings?

Pupil: Since the advent of solvent refining of lubricating oil, there have been various articles published from time to time in regard to operating characteristics, investment costs, operating costs, and quality of finished oil. To my knowledge there has never been a comparison made and published, and it is the purpose of this discussion to make a brief comparison of the present solvent refining processes that are being used on a commercial scale. Undoubtedly this comparison will be of a general nature and these figures are not to be taken with too much emphasis. So many various kinds of charging stocks have been used and results tabulated that are entirely different that in fairness to all processes it is only right that we use average figures.

In the single solvent extraction processes, we find that Furfural has the edge in that in processing heavy Mid-Continent distillate a ratio of 2:1 solvent to oil ratio was used. The loss, which was 0.038 percent solvent loss per bbl. of solvent used, was 32 gal. per day for a 1000-bbl. unit. Basing all costs on New York prices as printed by a leading chemical engineering magazine,[1] we find that Furfural is approximately 96 cents per gal. or a cost of 2.9 cents (approximately 3 cents) per bbl. of oil charged. The plant investment will be approximately $200 to $300 per bbl. Chlorex when processing Mid-Continent wax distillate and using a 3:1 solvent to oil ratio will have a loss of approximately 0.10 percent per bbl. of solvent used, or 126 gal. per day for a 1000-bbl. unit. At a cost of $1.97 per gal. f.o.b. New York, this will amount to 18 cents per bbl. oil charged. The investment in this instance for Chlorex will be much lower, or about $80 to $110 per bbl.

Phenol used on a Mid-Continent slop wax distillate with 1¾:1 solvent to oil ratio shows a loss of 0.15 percent per bbl. of solvent, which is equivalent to 110 gal. per day. Phenol f.o.b. New York costs approximately $1.30 per gal., so the solvent cost per bbl. of oil charged is 14 cents. I could not find any investment costs.

The Nitrobenzene processes used successfully on Pennsylvania stock showed in running Pennsylvania distillate a loss of 0.20 percent per bbl. of solvent when using 2:1 solvent to oil ratio. This is equivalent to 168 gal. at 0.85 cent per gal. f.o.b. New York or a cost of 14 cents per bbl. charged. The investment costs on these units are about $275 per bbl.

From the standpoint of solvent cost per bbl., the Furfural unit shows up superior whereas Chlorex has the cheapest installation cost. The yields on these four single solvent processes show that Phenol is the best at 80.4 percent on the stocks as processed.

There are two double solvent extraction processes that are used extensively and both are recommended highly for lube oil extraction. Especially is this true of the Duo-Sol process, which the distributors assert will process successfully all kinds and types of charging stocks. In a plant that has been operatting for some time on Mid-Continent residual cylinder stock using a 3:1 solvent to oil ratio, a very good result was obtained. The solvent was made up of propane as the paraffinic layer extractor and Selector using 60 percent phenol and 40 percent cresylic acid was used for the so-called naphthenic or undesirable lube oil constituents. The propane and Selecto were blended 50-50 so that the solvent price of $1.14 is based on the Selecto price, as propane loss is negligible. The solvent loss was 0.02 percent, which amounted to 84 gal. per day or 9.2 cents per bbl. of oil charged. The investment cost is approximately $445 per bbl., which is fairly high as initial costs go. There is about ½-cent per gal.

(Continued on Page 145)

[1]Editor's Note: These quotations may not be in effect today.

(Continued from Page 142)

charged for royalty, however, that is equivalent to 21 cents per bbl., which added to 9 cents, makes a total of 30 cents per bbl., which is higher than the average cost of solvent refining processes.

The Edeleanu process is being used on processing Kettleman Hills propane-treated residuum. The solvent to oil ratio was 2½:1 and an average loss of 12 cents per bbl. of solvent is equivalent to 126 gal. The cost of the combined solvent composed of sulphur dioxide and benzol is 36 cents per gal., which makes a solvent loss cost of 4½ cents per bbl. charged. This cost is very low in comparison to the other processes and the distributor claims a good grade of finished oil, but the yield is very low, being about 35 percent on this stock. The yield on Duo-Sol process was very good, running about 78 percent of raffinate oil, which very much overbalances the low yields obtained on the Edeleanu process.

Two processes are used extensively in dewaxing oils, but in all cases these dewaxing processes follow the solvent extraction process.

The Methyl-Ethyl-Ketone process, which was operated on raw Oklahoma City residuum charge, is giving good results at low cost. A 3:1 solvent to oil ratio was used and at a loss of 0.05 percent the total cost is only 2.4 cents per bbl. of oil charged. Again the investment cost is rather high, approximately $500 per bbl.

The Benzol-Acetone process is very similar to the Methyl-Ethyl-Ketone process with a higher loss of 0.20 and an equivalent cost of 8⅓ cents.

To obtain a more accurate picture of the comparable cost, an analysis of all processes when operating on the same charging stock, i.e., Mid-Continent long residuum for this territory, would give us some very interesting information. Unfortunately, there has been no commercial plant operation on which to get this comparison, but by some interpolation and data from experiments, etc., we are able to arrive at some comparable figures. The following data, therefore, are based on operating all processes on Mid-Continent long residuum of approximately 22° A.P.I. gravity to yield a 95 viscosity index oil.

The Chlorex process, operating on the same charge, will require a 9:1 solvent to oil ratio and at a total cost of approximately 69 cents per bbl. charge, the yield also is low at about 50 percent.

The Phenol process also operating on same charge as above, requires about a 6:1 solvent to oil ratio with a cost of about 48 cents per bbl. exclusive of operating costs, which will undoubtedly run approximately 15 to 30 cents per bbl. or a total cost of 63 to 78 cents per bbl. charge. The yield is a trifle better than Chlorex with about 55 percent.

The Nitrobenzene process on the same charge and about 4:1 solvent to oil ratio will cost about 59 cents per bbl. charge, including operating costs. The yield is fairly good at 60 percent.

The Duo-Sol process will require about a 3:1 solvent to oil ratio and will cost from 24 to 39 cents per bbl. charge, including operating cost. The yield is very good at 75 percent, thus making Duo-Sol an outstanding process for this type of charging stock.

The Edeleanu process will require about 2½: 1 solvent to oil ratio and cost about 5 cents per bbl. exclusive of operating costs, which I understand are high, but the yield is low at only 45 percent.

In the dewaxing processes used on this same Mid-Continent long residuum, the results will be similar to our above-mentioned sample run, which would use 3:1 solvent to oil ratio and at a cost of 17½ cents to 32½ cents per bbl. charge, which is in line with average costs. This is for the Methyl-Ethyl-Ketone process. The Benzol-Acetone process is very similar in costs and results, both processes yielding from 85 percent to 88 percent of the charge; however, these processes are both used after the oil has been solvent extracted.

As a general comparison of the conventional naphtha-oil blend methods of extracting the wax following the acid treat, we might add that in a recent plant operation it was found that when charging a Mid-Continent heavy wax distillate and Oklahoma City stock blend, an agitating cost or treating cost of 63 cents per bbl. of finished oil resulted. This cost included operating, labor, and chemical costs. The centrifuge dewaxing costs were 42 cents per bbl. of finished oil.

The naphtha or solvent losses were about 10 percent of charge to centrifuge plant, which at 3½ cents per gal. would cost about 14⅓ cents per bbl.; charge to centrifuge. The yield on the naphtha solvent process only ran about 63 percent.

A brief glance at these comparisons indicate to my mind that the solvent processes are somewhat cheaper, but that to obtain a certain product of certain characteristics and to be able to use all charging stocks, the Duo-Sol process may come nearer to serving the needs; however, all the processes have distinctive advantages with certain charging stocks so that each refiner must individually determine his own final product characteristics then fit the process to this product.

Pupil: The cost over here (referring to a particular process)—is that the finished oil?

Pupil: That is just the solvent cost. There is no operating cost added in these figures at all, and the oil referred to is only taken through this one type of unit.

Pupil: These figures are finished cost?

Pupil: No; it depends on your charge in lots of cases.

Pupil: What about the cost of 62 cents per bbl?

Pupil: That is chemical, treating loss, and labor.

Leader: Suppose we accept on faith that the long residuum is worth $1.25 per bbl. It is worth more than a fuel oil price. You cannot afford to run any skimming operations for a fuel oil price; 1000 bbl. at $1.25 would be $1250—we would operate at 20 cents or maybe add the two and get 30 cents. Would that be reasonable for operating and solvent?

1000 @ $1.25	$1250
1000 operating and solvent @ 30 cents	300
	$1550
Credit	
Extract 350 bbl. at 60 cents	$ 210
650 bbl. of oil	$1340

$ 2.06 per bbl.

We will say the extract is not good for anything but cracking stock with a rather low gasoline return. I believe 60 cents per bbl. would be liberal.

Class Meeting No. 9

Leader: At last meeting we began to figure the cost of solvent treated oil per bbl. We assumed $1.25 is the value of residuum produced by the skimming operation; with 1000 bbl. total value would be $1250. We used 30 cents as the cost per bbl. for operation of the solvent process, or a total of $300, which, added to the $1250, gives a total expenditure of $1550. We have a credit of 60 cents per bbl. for extract and, assuming we had 350 bbl. of extract, the credit from this source would be $210, leaving a total cost of $1340 for 650 bbl. of raffinate. This shows an investment of $2.06 per bbl. We will then dewax and lose some more on the 650 bbl. of raffinate. What do you suggest we do with this fraction—we have a long residuum?

Pupil: I would work it both ways to show what the difference is between making and losing money.

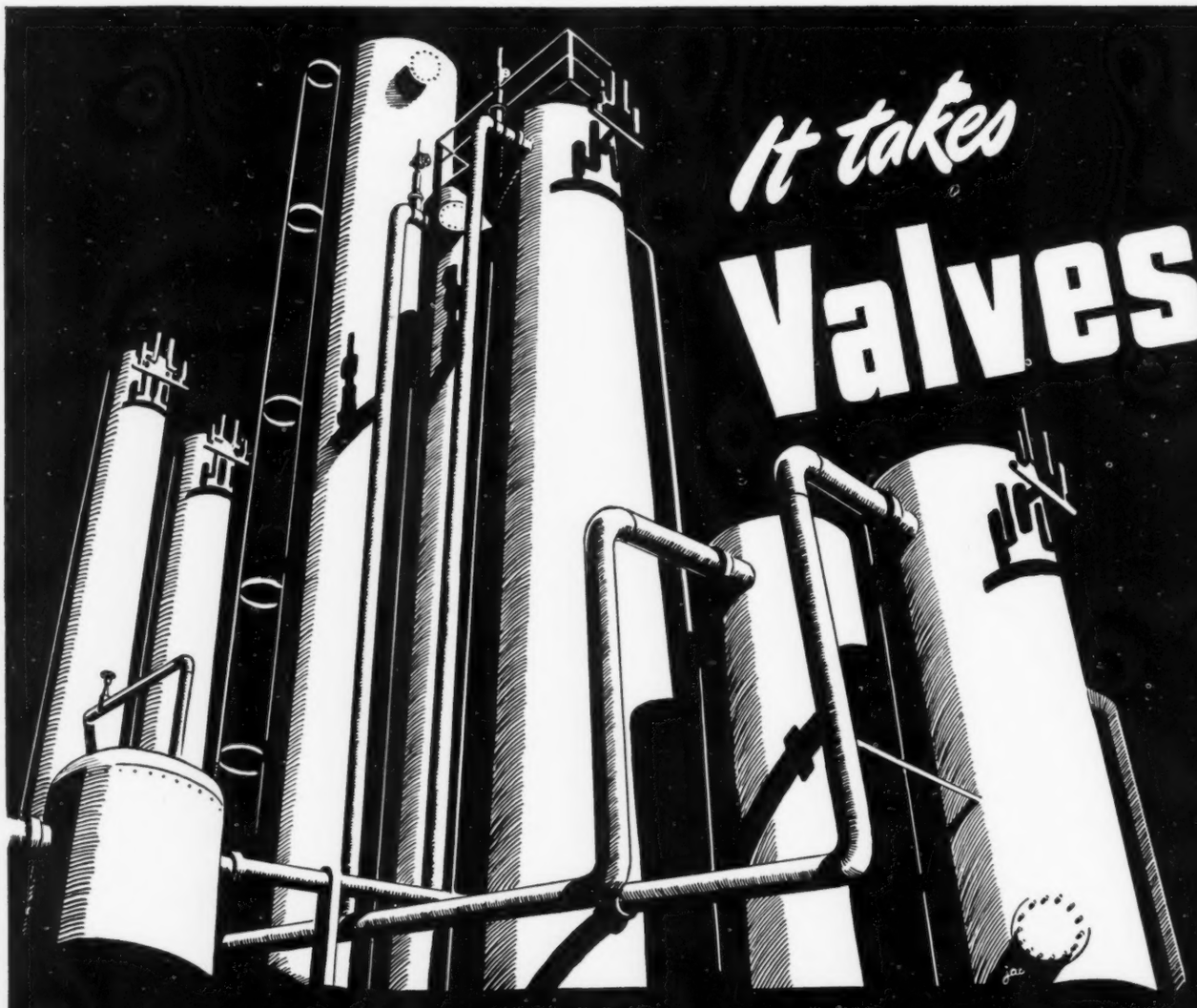
Leader: We will assume everything we dewax is going to cracking stock. What yield should we expect?

Pupil: Off the long residuum?

Leader: Yes.

Pupil: The yield of petrolatum should be about 22 percent.

(Continued on Page 148)



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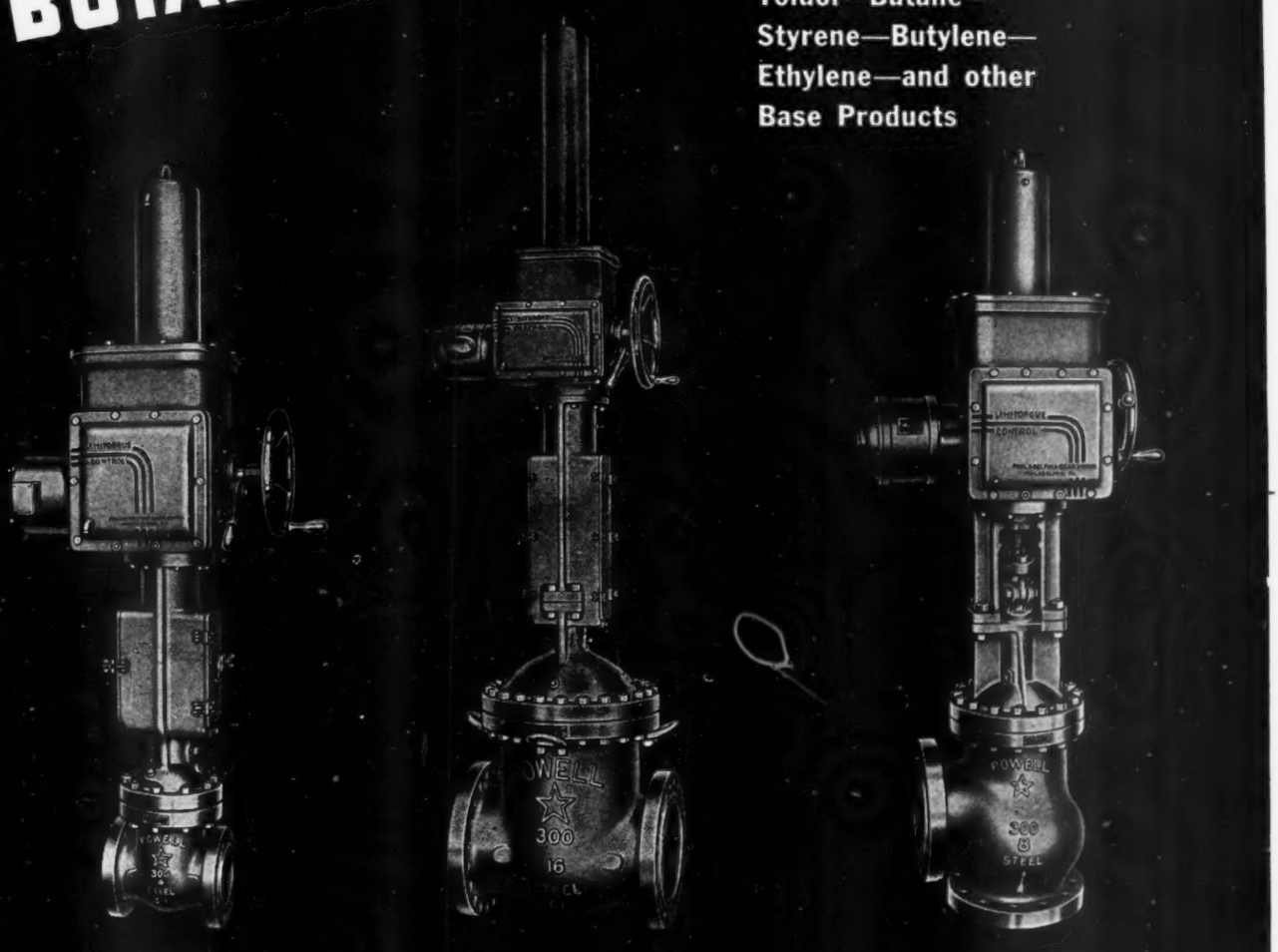

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VALVES

(Continued from Page 145)

Leader: You would then suggest that about 78 percent will be recovered as a dewaxed raffinate?

Pupil: 508 bbl. are left.

Leader: We will show it as follows:

Value of raffinate	$1340
Petrolatum (142 bbl. @ $1.15, cracked value)	163
	$1177
Centrifuging (cost of dewaxing @ 30 cents per bbl.)	195
Investment in 508 bbl. dewaxed raffinate	$1372

Pupil: That is $2.70 per bbl.

Leader: Now what are you going to do with it? Shall we put it through a still now that we have dewaxed, removed asphalts, and resins, etc.? One way would be to split it into fractions. The light and heavy oils are about the same price but it would be necessary to get it into usable fractions.

Leader: How much will it cost to split up to commercial grades?

Pupil: Including investment, 10 cents per bbl.

Leader: To continue our tabulation:

Investment in raffinate	$1372
Cost to still—508 bbl. @ 10 cents per bbl.	51
	$1423

Now for percolation or contact as the final finishing up of this oil. We will use the term "filtration."

Pupil: There will be loss in filtration.

Leader: Yes, that must be accounted for.

Pupil: Any acid treat?

Leader: No. We will dodge that route and assume the deasphalting was with the Duo-Sol unit. What is the cost of filtration?

Pupil: Including investment, 15 cents per bbl.

Leader: The figure obtained at 15 cents is approximately $76. This sum added to $1423 totals $1499. Now how much viscous oil has been lost?

Pupil: Not more than 3 percent.

Leader: We would have 97 percent of 508 bbl. or 492 bbl., which, divided into $1499, gives $3.03 per bbl., the complete cost not including investment in the unit itself. We had an investment of $500,000 on a 1000-bbl. unit. How long should be necessary to retire the unit?

Pupil: Ten years.

Leader: Obsolescence would probably take it in that period. I assume the 30 cents per bbl. takes care of maintenance costs. We will make the write-off in 10 years, plus taxes, insurance, royalties, etc.

Pupil: That would be one-fourth of the investment.

Leader: Let's use $20,000 as the figure, which brings the amount to $70,000 to split up into 492 bbl., or 39 cents per bbl.

Pupil: Does the $500 per bbl. figure include write-off on other units such as filtration and dewaxing?

Leader: They are subsidiary units. It is necessary, after interest, return on investment, royalties, etc., are taken to arrive at a figure of from 9 to 12 cents to get in the range of competition.

Pupil: We are not taking advantage of any credit oils.

Leader: Yes, we have taken those as we went along.

Pupil: What is the market price of that oil now?

Leader: Somewhere around 11 to 12 cents per gal. We have given credit all the way through and favored the remaining product.

Pupil: How does this compare in cost with the sulphuric acid process?

Leader: Somewhere fairly close to it.

Pupil: We started a low yield on that 65 percent Duo-Sol.

Pupil: There is a possibility of 10 percent yield improvement above that figured.

Leader: We made good viscosity index.

Pupil: We take care of all the treating losses there though.

Leader: We use 30 cents per bbl. to see what that wax would do. That makes a great difference in the figures.

If we may assume that before the Methyl-Ethyl-Ketone dewaxing, we split it up in fractions to obtain one cut of light motor oil, which, when dewaxed, is salable. So the next step would be to take the raffinate and distill it at the 15 cents per bbl. figure. Although this may give us several fractions, the proportion of difference is in separation. Now we have to decide how much of that there will be. How much wax on an original crude oil should there be after it is sweated.

Pupil: After percolation?

Leader: Yes, when the wax is finished.

Pupil: One percent is about right.

Leader: I believe 2½ percent wax is correct on the crude in this instance. There would be about 35 lb. per bbl. of crude scale wax from which is obtained 25 lb. per bbl. wax. If we obtain 35 lb. per bbl., we must guess what this light fraction is. It would perhaps be 5 to 6 percent on crude, or 12 percent on this yield, about 125 bbl. So 35 percent is a good yield from 125 bbl.

Pupil: You would have more light fraction?

Leader: Yes, we would—say 200 bbl. We would have a credit for 35 bbl. of slacked wax. This wax is worth considerably more than the conventional processed wax. I have not figured lately, but suppose it were finished wax, could you estimate the value of the slacked wax.

Pupil: The slacked wax would yield about 70 percent.

Leader: The finished wax is selling for what?

Pupil: Must be about 32 cents per gal.

Leader: Using a figure of 17 cents on the finished product, which is about right on this charging stock, we have: 42 gal. × 17 cents = $7.14 per bbl.

Pupil: That would give us a total value of 35 × 42 × 28 = $411.60.

Leader: You can see we are getting into money fast saving wax. We have spent $1438. Now we must get the rest of the credit. What yield from petrolatum?

Pupil: Methyl-Ethyl-Ketone?

Pupil: 15 percent on charge.

Pupil: 16 percent is probably nearer.

Leader: 16 percent of 450 bbl. is 72 bbl. at $1.15 per bbl. or $83.00. How much is the Methyl-Ethyl-Ketone operation, 30 cents?

Pupil: That 30 cents would cover the cost of solvent.

Leader: The Methyl-Ethyl-Ketone operation would be: 650 bbl. at 30 cents per bbl., or $195.

Pupil: Do we put the entire 650 bbl. through Methyl-Ethyl-Ketone?

Leader: Yes.

Leader: Deducting our previous credits, we have $1140 tied up in 650 bbl. minus 107 bbl., which would be 543 bbl. Now we filter it and we are through. They were already separated, presumably. What did we decide on the filtering costs?

Pupil: 15 cents.

Leader: That would be about $82 for filtration. Now, with 97 percent yield, we have what?

Pupil: 528 bbl.

Pupil: The $1140 should be added.

Leader: That is correct. $1140 + $82 = $1222 divided by 528 = $2.23 per bbl. We then have the following table:

Duo-Sol worth (per year)	$ 50,000
Methyl-Ethyl-Ketone (about 65 percent)	33,000
Taxes, insurance, etc. (1 unit)	35,000
	$118,000

365 days × 528 bbl. = 194,300 bbl., or 61 cents (118,000 divided by 194,300)

$2.23
0.61

$2.84 per bbl. or 6.8 cents per gal.

(To be Continued)

☆ ☆ ☆

Reading Pulsating Flows On An Orifice Meter Chart

☆ A method that results in determinations having error of less than 3 percent

by H. H. Beeson

Vice-President and Chief Engineer, Sabine Valley Gasoline Company

H. H. BEESON

received a bachelor of science degree at Iowa State College in 1932—Worked with the Iowa Engineering Experiment Station on utilization of butane until 1934—Has been in the natural gasoline industry since that time—Is chief engineer and vice-president of Sabine Valley Gasoline Company.

THE orifice meter has proved to be a valuable instrument for measuring gas flows. It is sometimes a serious problem to read correctly the chart that records flow of the gas. Many charts are easy to read when the recording pen arms make smooth curves, but on irregular and pulsating flows questions arise regarding the values that should be read as representing the correct flow.

If the meter is used to measure a pulsating flow such as gas from a well that "heads" in its flow, the differential pen arm will move back and forth over a range of several inches, leaving a wide mark. The question then arises, where is the correct reading found to give an average differential for the whole flow? Different chart readers use values ranging from 0.3 up to 0.6 of the pulsating flow range. Fig. 1 shows the type of chart measuring a pulsating flow.

In order to determine the correct reading for a pulsating flow of gas, it

(Continued on Page 154)

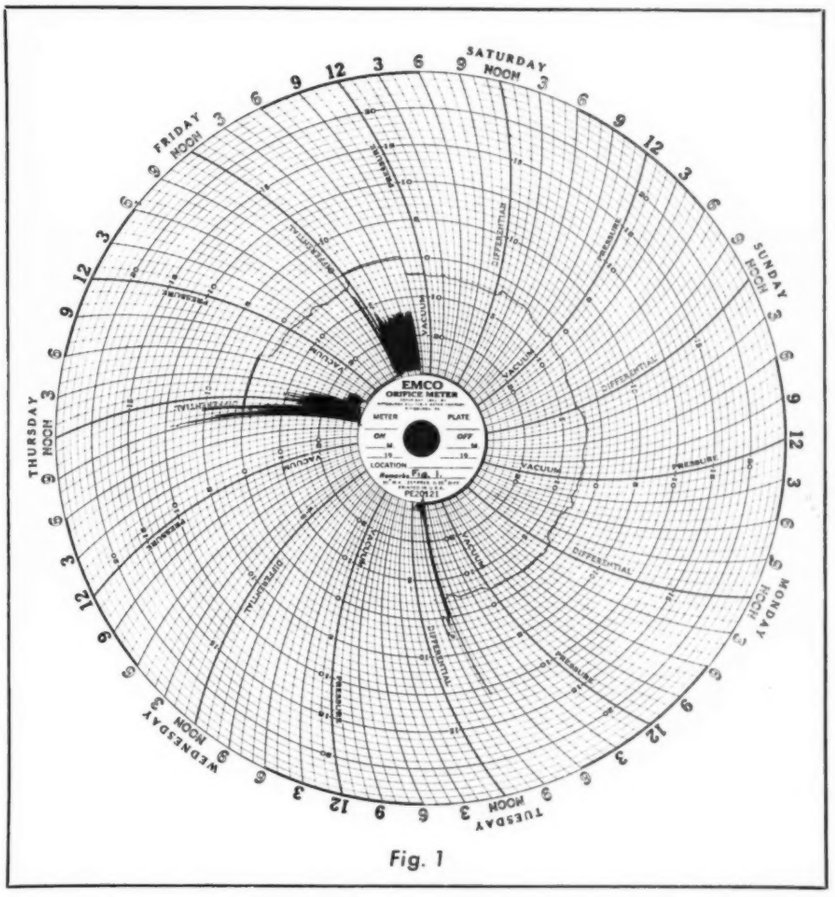

Fig. 1

TABLE I
Integrator calculations

Time start	Time stop	Differential range	Reading			Hourly extension	Average differential
			Start	Stop	Difference		
5 a.m.	6 a.m.	5–15	6934	7005	71	50.20	8.01
6 a.m.	7 a.m.	5–10	7005	7070	65	45.96	6.72
7 a.m.	8 a.m.	5–15	7070	7142	72	50.90	8.24
8 a.m.	9 a.m.	0–10	7142	7187	45	31.82	3.22
9 a.m.	11 a.m.	0–10	7187	7278	91	32.17	3.29
11 a.m.	1 p.m.	20–30	7278	7517	239	84.49	22.71
1 p.m.	3 p.m.	30–40	7517	7802	285	100.75	32.29
3 p.m.	5 p.m.	10–20	7802	7987	185	65.40	13.60
5 p.m.	8 p.m.	10–20	7987	8264	277	65.28	13.55
8 p.m.	10 p.m.	5–10	8264	8396	132	46.66	6.92
10 p.m.	12 p.m.	5–20	8396	8559	163	57.62	10.56
12 p.m.	2 a.m.	5–20	8559	8719	160	56.56	10.17
2 a.m.	5 a.m.	0–5	8719	8815	96	22.62	1.63

Pressure remained constant at 300 lb. ga.
Integrator constant at 0.707.

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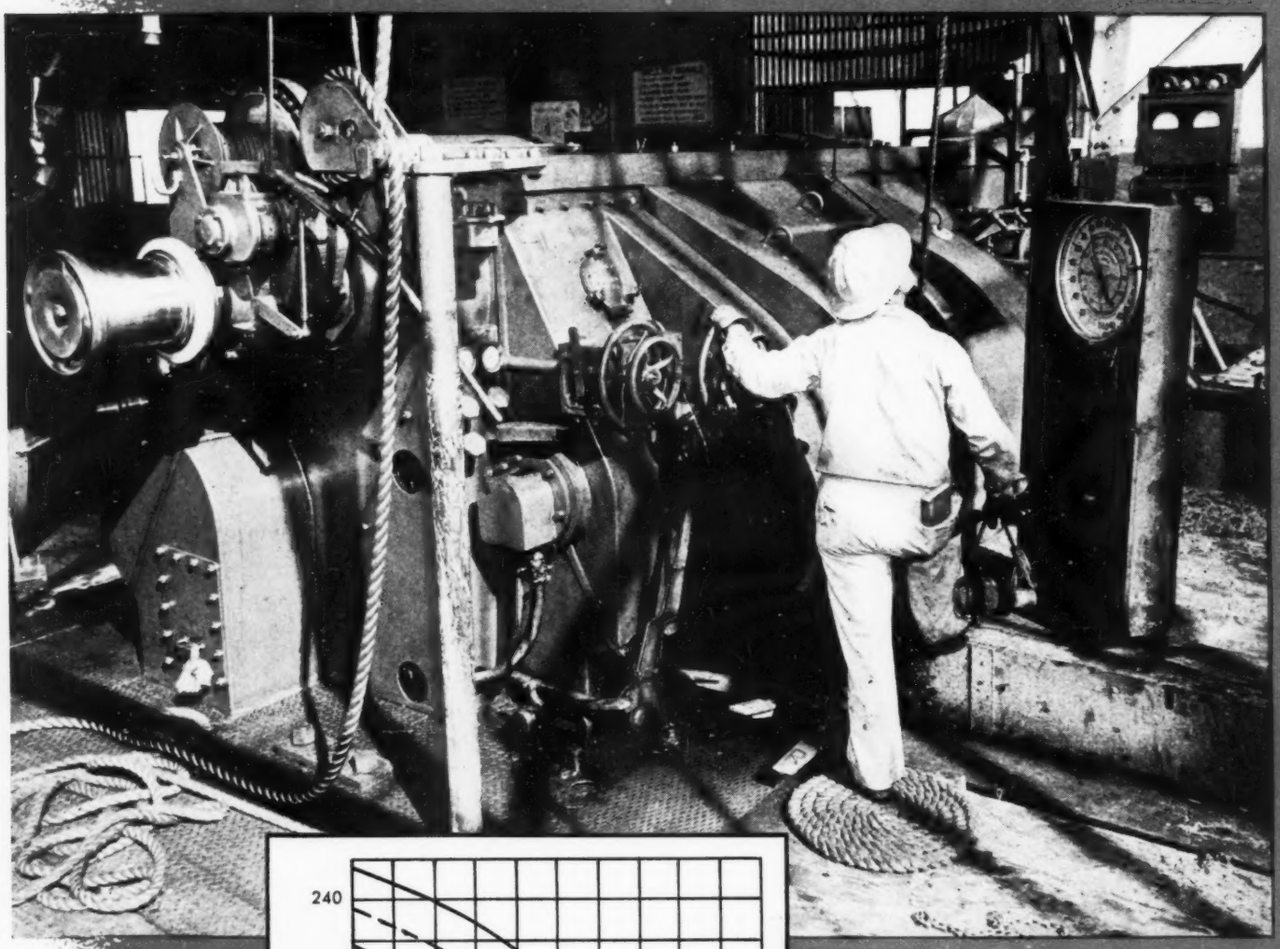

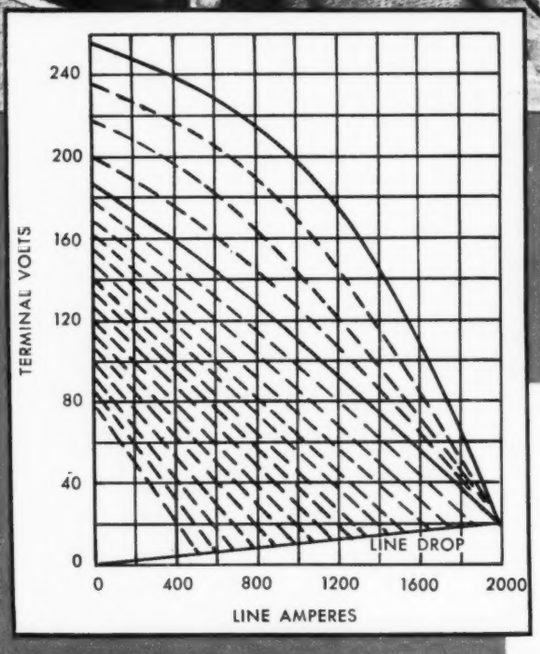

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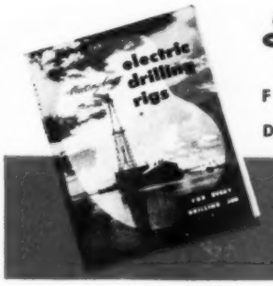

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(Continued from Page 151)

was decided to make up such a chart on an integrator from which the correct average differential reading could be calculated. A blank chart was placed on an Emco-McGaughy integrator and a pulsating differential made by rapidly moving the differential pen arm back and forth. Readings on the indicator were taken at intervals covering a definite range of pulsations. Fig. 2 is the chart used in making these determinations. Table 1 shows the differential ranges and the integrator readings obtained, which have been calculated to give the hourly extensions. By squaring the extension and dividing by the absolute pressure, a correct average differential reading was obtained.

Calculations were then made to determine whether some kind of an average of the differential range could be used to give the correct differential. Inspection of the results showed that the arithmetic average followed the true differential but was too high. Ratios of the differential ranges to the true differentials of the ranges were then set up and these ratios all approximated one-third. This indicated that a correct differential reading would approximate the low reading plus one-third of the range. Table 2 shows the extensions calculated by this means and shows the percentages of error against the true extensions obtained from the integrator.

These calculations show that the method described here is a very close method of reading a pulsating flow on a chart, the error being less than 3 percent, which is within the accuracy of reading charts. This applies not only to reading a chart by inspection but also in using an integrator where the pen arm is run across an average differential. It must be noted that this method could not be used where the pulsations are of high frequency such as at the discharge of a compressor. Any error in the meter for recording a pulsating flow of gas through the meter would not be compensated.

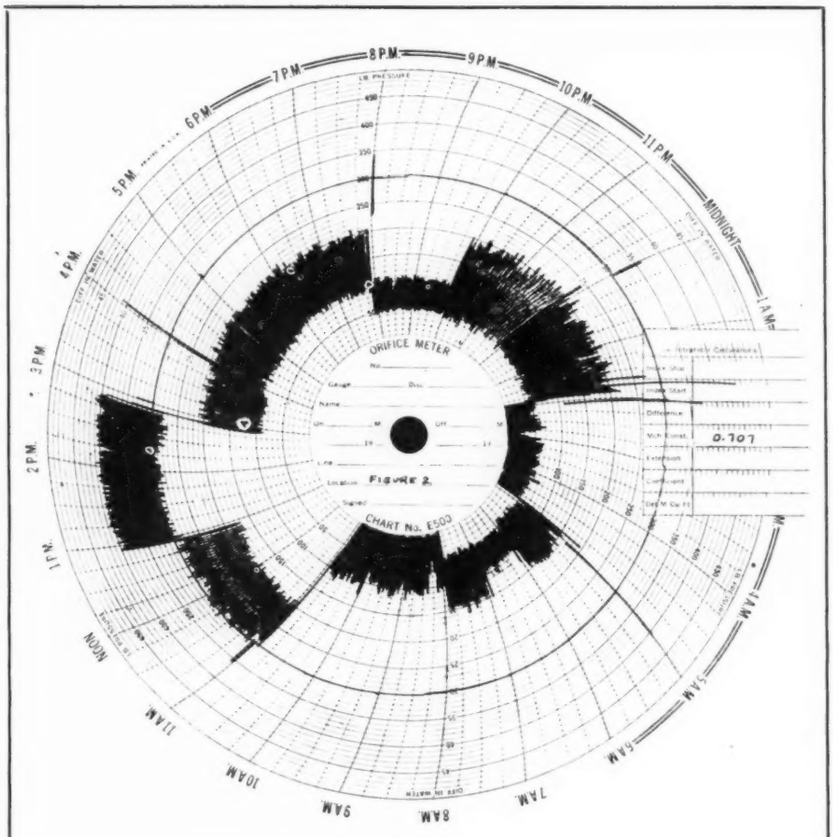


Fig. 2

TABLE 2
Inspection calculations

Time start	Time stop	Differential range	Differential difference	One-third difference	Correct differential	Hourly extension	Correct extension	Error	Percent error
5 a.m.	6 a.m.	5-15	10	3.3	8.3	51.08	50.20	+0.88	+1.75
6 a.m.	7 a.m.	5-10	5	1.7	6.7	45.90	45.96	−0.06	−0.13
7 a.m.	8 a.m.	5-15	10	3.3	8.3	51.08	50.90	+0.18	+0.35
8 a.m.	9 a.m.	0-10	10	3.3	3.3	32.21	31.82	+0.39	+1.23
9 a.m.	11 a.m.	0-10	10	3.3	3.3	32.21	32.17	+0.04	+0.12
11 a.m.	1 p.m.	20-30	10	3.3	23.3	85.59	84.49	+1.10	+1.30
1 p.m.	3 p.m.	30-40	10	3.3	33.3	101.96	100.75	+1.11	+1.10
3 p.m.	5 p.m.	10-20	10	3.3	13.3	64.66	65.40	−0.74	−1.13
5 p.m.	8 p.m.	10-20	10	3.3	13.3	64.66	65.28	−0.62	−0.95
8 p.m.	10 p.m.	5-10	5	1.7	6.7	45.90	46.66	−0.76	−1.63
10 p.m.	12 p.m.	5-20	15	5.0	10.0	56.07	57.62	−1.55	−2.69
12 p.m.	2 a.m.	5-20	15	5.0	10.0	56.07	56.56	−0.49	−0.87
2 a.m.	5 a.m.	0-5	5	1.7	1.7	23.12	22.62	+0.50	+2.21

Pressure remained constant at 300 lb. ga.

P 031.132

Analyses of Kansas Crude Oils

THE U. S. Bureau of Mines has issued a third report on analyses of crude oils from some of the major producing fields of Kansas, supplementing similar publications of 1922 and 1928. The report presents analyses of 174 individual samples, including distillation data and other characteristics such as specific gravity, color, viscosity, and sulphur content.

The State's cumulative production from 1889 to 1940, inclusive, which amounted to 1,121,064,000 bbl., including the production of Oklahoma for the years 1905 and 1906, is tabulated on an annual basis. Other tables give information concerning the location, the date of discovery, depths and ages of producing sands, and cumulative production of individual fields. General characteristics of the crude oils also are tabulated from information obtained by the same methods of analysis and interpretation as outlined in earlier publications of the Bureau.

The analyses may be found in Report of Investigations No. 3688, "Analyses of Crude Oils from Some Fields in Kansas" by the late E. C. Lane, assistant petroleum chemist at the Bureau of Mines Petroleum Experiment Station at Bartlesville, Oklahoma, and E. L. Garton, assistant physical chemist at the same station.

The report recently was published by the U. S. Bureau of Mines, Department of the Interior, Washington, D. C.

Use of Chlorates in Refining High Sulphur Gasolines[1]

☆ Procedure used in treating gasolines obtained from "Second Baku" crude oils

by N. E. Vishnevskii
(Leningrad)

THE refining of oils from the new fields developed in Russia during the second Five Year Plan brought Russian engineers face to face with the new problem of desulphurizing the gasolines made from the crudes. Gasolines made from crude oils produced in the older districts of Russia did not require special desulphurization and a simple treatment with sulphuric acid removed not only the asphaltic substances but almost always was sufficient to remove the sulphur compounds. It was soon discovered, however, that such simple treatment was not sufficient for the gasolines obtained from "Second Baku" crude oils produced in the eastern part of European Russia. In the Saratov cracking plant, for example, where prior to 1940 almost all crude oil from the Second Baku was refined, the sulphur content of the gasoline (0.39 percent) was lowered only to 0.275 percent as the result of an alkali-sulphuric acid treatment or a reduction of only 37 percent. In fact, during June, 1939, refining lowered the sulphuric content of the gasoline only 27 percent, which was far from satisfactory and did not justify the comparatively high consumption of sulphur-reducing agents (sulphuric acid 0.6 percent and caustic 0.1 percent).

It was found that the reduction of the sulphur content of gasolines could be increased considerably by using hypochlorite in place of sulphuric acid and caustic. By using 4 percent calcium hypochlorite, for example, a gasoline containing 0.105 percent sulphur and 0.025 percent chlorine was obtained.[2] As the initial sulphur content of the gasoline after the removal of hydrogen sulphide with caustic was 0.39 percent, the effect of desulphurization with calcium hypochlorite was 73 percent.

An attempt is made in this report to prove (Fig. 1) that by the use of 0.1 percent chlorate instead of caustic it is possible to lower the sulphur content of the heavier Chusovo gasoline from 0.427 to 0.19 percent (55.5 percent) and that a reduction in the sulphur content to 0.07 percent can be expected when using 1 percent chlorate. Using a 1.8 percent chlorate, corresponding in cost to that of a 4 percent bleaching lime, a gasoline containing only 0.025 percent sulphur for a yield of 80 percent may be obtained—a 99.4 percent refining efficiency. Even for an efficiency of 94 percent the sulphur content will amount to only 0.055 percent. Thus, by using chlorate in the refining process it is possible to produce an aviation gasoline, instead of a second grade product as is obtained at present, from the same raw material. Furthermore, the resulting gasolines are in no way inferior to those obtained by catalytic pressure hydrogenation, which when operated under 15 atmospheres of pressure at a temperature of 350°C. in the presence of 5 percent MoS_2, reduced the sulphur content of the Chusovo gasoline having an endpoint of 200°C. and containing 0.47 percent sulphur to 0.03 percent.

The use of chlorates in the refining of gasolines is not limited only to those made from Second Baku crude oils. It may be applied also to cracked gasolines (gasolines from shales and bogheads) to which the known methods of desulphurization are not applicable.

The present seemed to be an opportune time to investigate the problem of using strong oxidizers in the treatment of gasolines high in sulphur. Initial investigations revealed that chlorates are among the most efficient oxidizers. They are a chemical product of which thousands of tons are produced annually in Russia. In fact, the manufacture of chlorates has become one of the large chemical industries capable of serving not only the home market but the export trade as well. Obviously, the consumption of chlorates will increase greatly if they are used by the petroleum refining industry and it will be possible to utilize waste chlorine and cheap lime for the production of calcium chlorate. To produce one ton of $Ca(ClO_3)_2$, 2.06 tons of chlorine and 1.62 tons of CaO are required.

The manufacture of chlorates can be combined also with that of combined nitrogen inasmuch as in the preparation of one ton of $KClO_3$ by the electrolytic method for a consumption of 7000 kw-hr. of electricity, 0.049 tons of hydrogen are generated, and for the production of one ton of $NaClO_3$ the quantity of hydrogen generated is 0.056 tons. Thus, the use of chlorates in the petroleum refining industry not only will permit the manufacture of high grade gasolines from high sulphur oils of the Second Baku, but will provide a need for expanding the chlorate industry.

Experimental Data

Reagents. Commercial potassium chlorate of domestic origin and containing 0.01199 percent Cl′ was used as the main reagent in the experiments. A comparison of a saturated solution of potassium chlorate at 20°C. with a sat-

(Continued on Page 160)

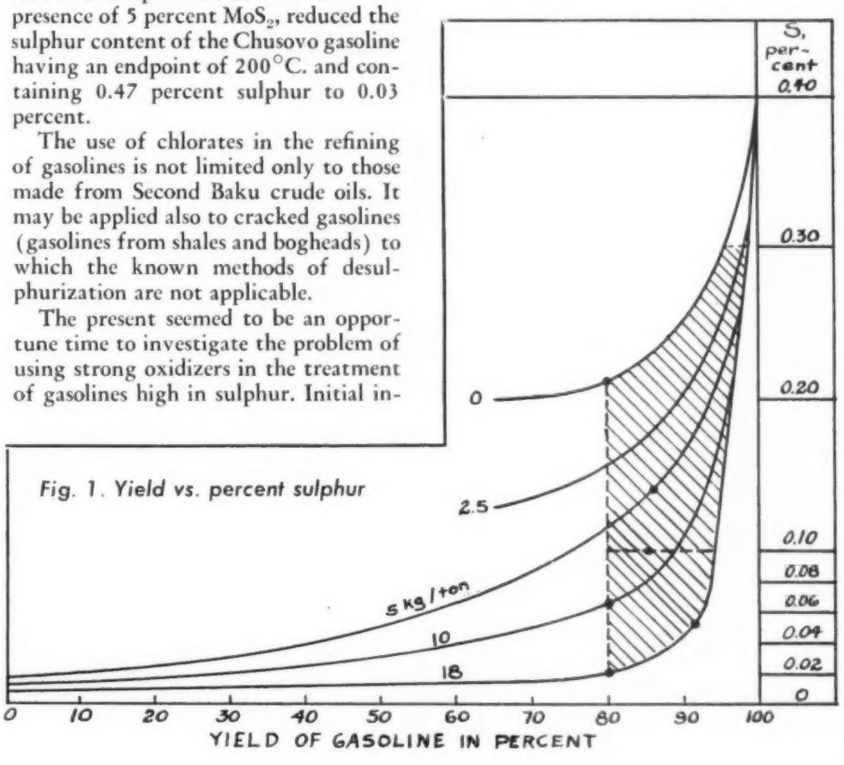


Fig. 1. Yield vs. percent sulphur

[1]Translated from the Russian oil journal *Vostochnaya Neft*, No. 9, 1940, by A. A. Boehtlingk, Berkeley, California.

[2a]Refinery-Scale Experiments on the Desulphurization of Gasoline From Ishimbaevo With Hypochlorite," by B. A. Englin, *Neftyanoe Khozyaistvo*, No. 8, 1939. See English translation in *Foreign Petroleum Technology*, 8, 54 (1940).

★ ★ ★ A New Pneumatic

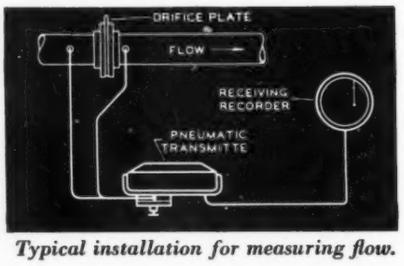
FOR MEASURING FLOW AND LEVEL

Operating on the Force-Balance Principle

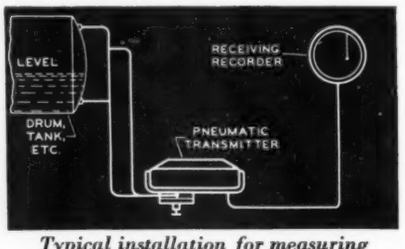
The Republic Differential Pressure Transmitter is an entirely new type of pneumatic meter which has been thoroughly field tested during the past two years. It is a simple pneumatic device for converting a differential pressure, such as is produced by the flow of a fluid through an orifice or by liquid level in a vessel, into an air pressure which varies proportionately with the differential pressure.

This air pressure is used as a direct measure of the differential pressure and can be conducted to a remote location by means of tubing. A gage or receiver connected anywhere in this transmission line will show the variations in the differential pressure and may be graduated in terms of the flow or level which it represents. The pressure can also be utilized as the impulse for actuating a controller.

The Republic Pneumatic Transmitter operates exactly like a weigh scale. The force of the differential pressure on a measuring diaphragm is the value being weighed. This force, multiplied by its lever length, is balanced by the force on a reaction diaphragm times its lever length. The pressure on the reaction diaphragm represents the weights used on a scale and is merely a means of automatically accomplishing this weighing process and transmitting the results.



Typical installation for measuring flow.



Typical installation for measuring liquid level.

RANGES—standard ranges are available from 0.9 in. to 25 in. of water differential, for working pressures up to 15 psi.; 7 in. to 50 in. of water for working pressures up to 25 psi.; and 13 in. to 800 in. of water for working pressures up to 600 psi. Special heads can be provided for working pressures up to 2000 psi.

RANGE EASILY CHANGED—the range of a Republic transmitter can be readily changed by making a few minor adjustments or substituting a few simple parts. For example, a transmitter with a differential range of 50 in. of water can be changed to any range up to 100 in. of water by merely changing the position of the reaction diaphragm.

DIAPHRAGM MATERIAL—diaphragms for the Republic transmitter can be made from practically any material including rubber, synthetic rubber, Saran, brass, stainless steel, Monel, silver, etc. This is possible due to the extremely small motion required. (.010 in. for full scale reading). The material is specified in accordance with the solvent or corrosive action of the measured fluid.

●

For complete details write for Bulletin No. 43-4

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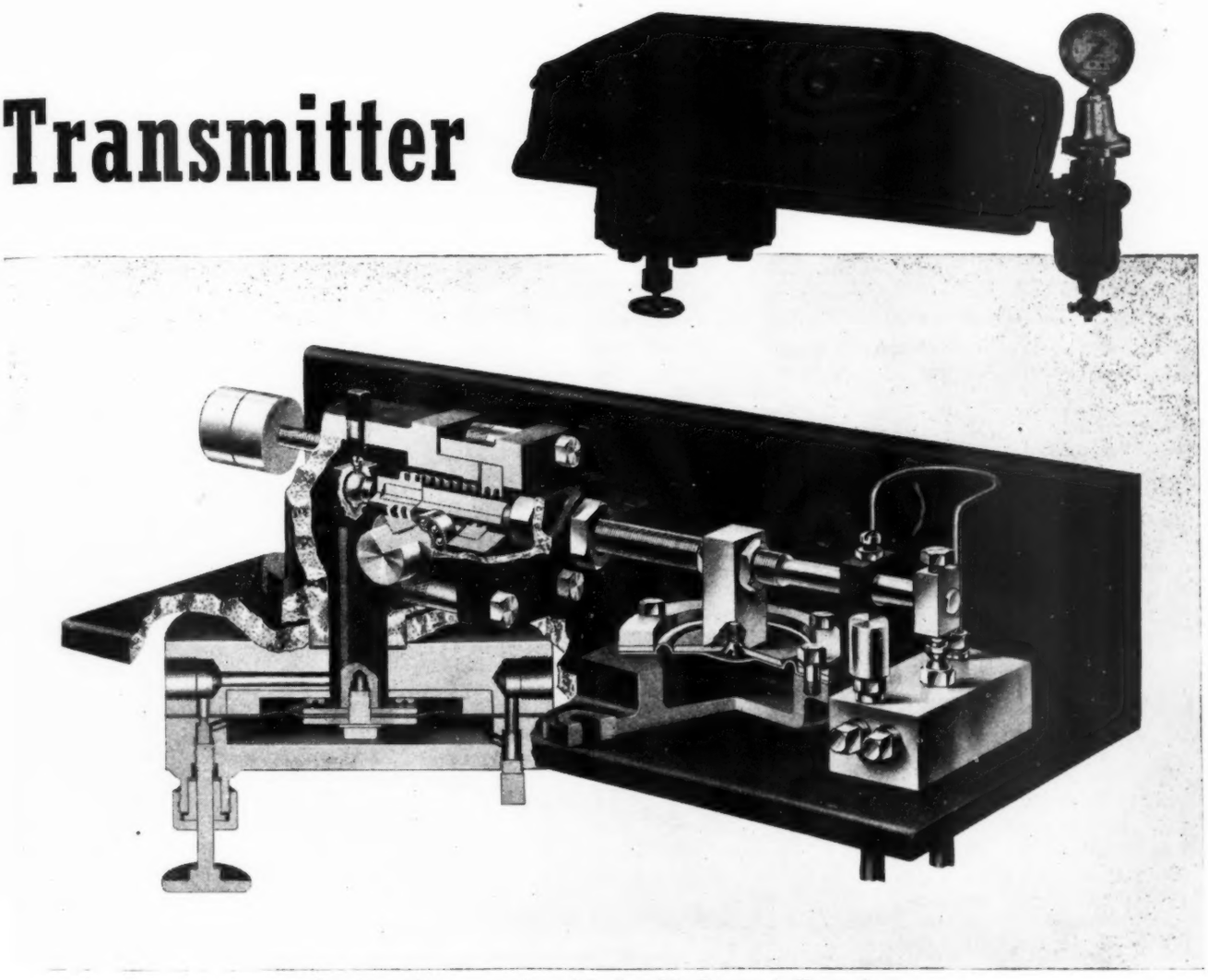
Transmitter



Exterior and cut-away view of the Republic Pneumatic Transmitter.

PERFORMANCE FEATURES

ACCURACY of the Republic force-balance method of measurement is higher than can be consistently secured and maintained with any other method. Transmitting pressure vs measured differential is guaranteed within ½ of 1% of meter range.

SENSITIVITY — due to the negligible motions required for complete operation of all parts for full scale change, no appreciable hysteresis results from reversal of direction of measurement change. The hysteresis loop is so small that it is undetectable by ordinary means, being less than 1/20 of 1%.

RESPONSIVENESS — due to the fact that there is virtually no volume displacement, the Republic Pneumatic Transmitter is able to follow flow changes almost instantaneously. The time required to produce full output pressure at the transmitter is in the nature of fractions of a second, after the differential is imposed. Therefore a receiving instrument installed adjacent to the transmitter will show flow changes almost instantly. With 500 feet of ¼ in. O. D. tubing, the full value of the change will have registered on a Republic receiver in 15 seconds. This is the overall lag in the system not merely the transmission lag.

NO TEMPERATURE EFFECT — the effect of ambient temperature variations on the accuracy of a Republic transmitter is negligible. Since all parts are equally affected by temperature changes, force and leverage relationships are not disturbed and accuracy is unimpaired.

NO VIBRATION EFFECT — the Republic transmitter is unaffected by any normal frequency of vibration ordinarily encountered in industrial or process plants.

AIR CONSUMPTION — the air consumption of the pneumatic system is .20 cfm. maximum at 20 psi. supply pressure, when differential is zero. At maximum differential consumption is zero and is inversely proportionate to intermediate, differentials.

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TABLE 1
Properties of Chusovo gasoline

Fraction boiling at indicated temperature, °C.	Yield in volume, percent	n_{20}	d_{20}	R	Sulphur, percent
40–100	24.2	1.4168	0.727	0.345	0.307
100–150	51.9	1.4513	0.792	0.341	0.200
150–200	21.8	1.4661	0.8225	0.337	0.668
200–225	2.1	1.4790	0.8515	0.333	3.78

Group composition: Aromatics 47 percent; Naphthenes 24 percent; Saturates 28 percent

(Continued from Page 157)

urated solution of sodium chlorate at the same temperature follows:

	$KClO_3$	$NaClO_3$
Content, percent	6.96	50.2
Grams per liter	72.7	718
Specific gravity	1.045	1.430

The following tabulation shows that potassium chlorate is a strong electrolyte characterized by a high degree of dissociation.

Concentration in grams equivalent per liter	*Degree of dissociation*
0.2	0.783
0.5	0.713
0.59	about 0.69
0.816	about 0.64

For comparison, the active oxygen content of potassium, sodium, and calcium chlorates, respectively, is:

$KClO_3 = 39.18$ percent
$NaClO_3 = 45.1$ percent
$Ca(ClO_3)_2 = 46.4$ percent

For chlorates to become effective oxidizers it is necessary to apply heat, to dissolve them in an acid solution, or to have some admixture (at least 1 percent) present. No spontaneous decomposition of the chlorates takes place. Chlorates, however, may be exploded through detonation, heavy impact, and through contact with red-hot surfaces (not with an open flame). $Ca(ClO_3)_2$ explodes with greater ease than either $KClO_3$ or $NaClO_3$. Admixtures of caustics (phlegmatizers) particularly aqueous solutions of caustics reduce the possibility of an explosion. $KClO_3$ is not hygroscopic but $NaClO_3$ is hygroscopic in air of a humidity above 60 percent.

The equation for the decomposition of chlorate is:

$$2KClO_3 \rightarrow KCl + 3O_2 + 21{,}800 \text{ calories}$$

The heat formed in the reaction may evaporate not more than 21,800 ÷ 539.1 or 40.5 grams of water. Thus, the "safe moisture" of potassium chlorate is:

$$\frac{40.5}{245.12 + 40.5} = 14.2 \text{ percent}$$

where 245.2 is twice the molecular weight of $KClO_3$. Actually, 2 to 3 percent moisture excludes the possibility of explosion as the velocity of the reaction for low percentages of moisture is very slow.

Two solutions were used in the experiments as oxidizing mixtures. Solution No. 1, used when heating the refined gasoline, consisted of a solution of the chlorate and sulphuric acid in the following proportion:

Sulphuric acid, 100 cc.	186 g.
Water	1000 g.
$KClO_3$	80 g.

The solution had a specific gravity of 1.144 g. per cc.; it was a transparent liquid with a characteristic odor of chloric acid; it decolorized dyes and indicators, bleached cork, and caused the appearance of an intensive blue coloration with diphenylamine. The solution turns green (as a result of the separation of additional amounts of $HClO_3$) when heated, but eventually the color disappears. The solution, however, is sufficiently stable so that it can be made up and stored for long periods of time.

The more active solution No. 2, was used when working with a propeller-agitator at ordinary temperatures. Solution No. 2 consisted of:

Sulphuric acid	1000 cc.
Water	520 cc.
$KClO_3$	80 g.

The acid had a specific gravity of 1.680, which corresponds to about 59° Bé. Such an acid does not polymerize unsaturated hydrocarbons and has no oxidizing properties. To obtain an oxidizing mixture, powdered $KClO_3$ was added to the acid on the basis of 100 grams of $KClO_3$ per liter of diluted acid. The specific gravity of the resultant solution was 1.780 and the concentration of chlorate was 0.816 gram equivalent per liter. The solution had a greenish-yellow color and gave off vapors of $HClO_3$. Therefore, the solution had to be prepared shortly before it was needed. The solution does not ignite such organic substances as filter paper, sugar, wood, gasoline, or rubber. Also, when moistened with gasoline, the chlorate powder does not ignite with a 75 percent solution of sulphuric acid although it decomposes with the generation of chloric acid and chlorine. One drop of concentrated sulphuric acid, however, is sufficient to ignite the powder.

Raw materials. Chusovo gasoline having the properties given in Table 1 was used in the first series of experiments.

The doctor test immediately gave a strong black coloration; hydrogen sulphide was not detected. From the fractions boiling at 100-150°C., 150-200°C., and 200-225°C. a fraction of heavy gasoline was prepared for which the following constants were determined:

$d_{20} = 0.8032$
$n_{20} = 1.4568$
$S = 0.427$ percent

Composition by weight

100-150°C.	68.5 percent
150-200°C.	28.3 percent
200-225°C.	2.6 percent

In the second series of experiments a gasoline derived from Moscow bogheads was used. The properties of the gasoline are given in Table 2.

The gasoline is a typical cracked gasoline that cannot be refined with sulphuric acid. The gasoline contained 1.005 percent sulphur; after washing with caustic the sulphur content was 0.997 percent. The doctor test caused the gasoline to turn yellow. The gasoline turned black in the doctor solution and a yellow precipitate formed in the presence of Cd″ before the alkali wash. Thus, the gasoline contained 0.008 percent hydrogen sulphide.

A fraction of heavy gasoline having the following properties was prepared from fractions boiling at 100-150°C. and 150-200°C.:

$d = 0.758$
$S = 1.089$ percent

Composition by weight

100-150°C.	65.8 percent
150-200°C.	34.2 percent

Apparatus: The refining of gasoline was carried out in a propeller-type agitator, which was a model of a commercial apparatus. The dimensions of the agitator were calculated in accordance with the theory of similarity.[3]

Capacity of the agitator	500 cc.
Diameter of propeller	0.04 meters
Width of the propeller	0.0112 meters
Pitch of the propeller blades	18 deg.
Number of revolutions	3000 per min.

[3] Cf. article by this author published in *Khimicheskoe Mashinostroenie*, No. 6, 1939.

(Continued on Page 164)

TABLE 2
Properties of Moscow gasoline

Fraction boiling at indicated temperature, °C.	Yield in volume, percent	d_{20}	n_{20}	Sulphur, percent
70–100	18.5	0.7115	1.4130	0.665
100–150	52.9	0.7522	1.4262	1.065
150–200	26.8	0.7834	1.4399	1.088
above 200	1.8	....	....	....
Mixture	100.0	0.758	....	0.997

components for Mechanical Draft Towers is wholly or in greater part in the hands of sub-manufacturers, the final delivery of a Mechanical Draft Type is dependent on these sub-manufacturers. On the other hand, the manufacture of an Atmospheric Aerator Type Cooling Tower is controlled by Fluor. Throughout the whole defense and war program Fluor has never failed to meet or beat scheduled delivery dates. This record will continue; Fluor is geared to do it.

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TABLE 3
Properties of gasoline fractions

Fraction boiling at °C.	Yield percent by volume	d_{20}	Chlorine, percent	Sulphur, percent	Weight percent of raw material	Total yield in percent	Percent sulphur at given yield
80–100	10.6	0.746	0.0118	0.018	11.3	11.3	0.0148
100–150	57.8	0.786	0.0138	0.021	53.1	64.4	0.0198
150–200	25.9	0.824	0.0356	0.087	25.2	89.6	0.0386
200–215	5.7	0.783	0.0794	0.700	5.2	94.8	0.0705

(Continued from Page 160)

The propeller is operated in a beaker covered with a lead lid through which the propeller shaft, a drop funnel, and a Beckmann thermometer pass. A vertical glass plate, i.e., a partition, was installed in the beaker to prevent the liquid from whirling with the propeller. When operating at the maximum number of revolutions, the efficiency of the agitator is such that an emulsion is formed with water and any kind of oil in 1 to 2 minutes. During the tests, the beaker with the agitator was placed in a glass water bath. Because partial chlorination of the gasoline takes place in the refining with chlorate it is necessary to check not only the sulphur content of gasolines but their chlorine content as well. The quantitative determinations of sulphur and chlorine were carried out by the lamp method, where a porous glass partition plays the basic role.

The products of the combustion of gasoline containing SO_2 were drawn through the cylinder equipped with a porous partition. Over this partition hydrogen peroxide had been placed before the experiment began. The products of combustion pass through the porous partition and rise in the form of bubbles through the hydrogen peroxide; this gives a large surface for contact of the phases and assures the complete oxidation of SO_2 to H_2SO_4. Simultaneously, the HCl formed in the combustion of the chlorides is absorbed. The acids were titrated in the course of the experiments with phenolphthalein.

A rapid determination of sulphur and chlorine was carried out as follows. A weighed amount of gasoline (2 to 4 ml.) introduced into a calibrated pipette permitted a direct determination of the specific gravity of the gasoline with an accuracy of 0.002 g. per cc. All solutions needed in the analysis were drawn from their containers by means of pipettes inserted into the plugs of the bottles to eliminate frequent control tests. It was found, for example, that 25 ml. of a 3 percent solution of H_2O_2 contained an amount of H_2SO_4 requiring 0.32 ml. of a solution of caustic for its neutralization and this amount of H_2SO_4 was subtracted from the amount of caustic spent in the titration.

The amount of chlorine introduced into the gasoline was determined after the determination of the total acidity. The volumetric ratio $KOH/AgNO_3 = 1.084$. Thus, if 10 ml. of $AgNO_3$ were spent in the determination of chlorine, the total amount of caustic spent in the neutralization of HCl was 10.84 ml. From the remaining caustic the amount of sulphuric acid and the percentage of sulphur in the gasoline could be determined.

For a gasoline having a high concentration of sulphur, the quantity used was such that 25 ml. of caustic would be required. Thus, for the Kashpira gasoline, 0.3 g. was sufficient, and to attain a uniform generation of SO_2 it had to be diluted with 2 ml. of aviation gasoline for which a preliminary correction was calculated for the sulphur content. The adopted procedure assured the determination of sulphur and chlorine to an accuracy of 0.002 to 0.004 percent with a relative error below 1 percent.

Refining Straight-run Gasoline[4]

First experiment. 40.1 grams of Chusovo gasoline, boiling at 100-225°C., were treated for 2 hours and 10 minutes in an agitator with solution No. 1 at 24-27.4°C. Loss by evaporation amounted to 2.24 percent as was established from the difference in the weight of the beaker and liquid before and after treatment. The acid layer produced a blue color with diphenylamine, thus indicating that the chlorate was not completely utilized. The separated gasoline was found to contain 0.40 percent sulphur. The gasoline then was washed with 10 ml. water and 10 ml. of NaOH of 6° Bé., and finally redistilled. The yield by volume amounted to 93.5 percent and the final boiling point was 215°C. The sulphur content was 0.369 and the gasoline contained 0.008 percent chlorine. Thus, the sulphur content had been decreased from 0.427 to 0.369, or only by 13.5 percent.

To determine the effect of the same oxidizing solution at a higher temperature, 23.7 g. of the gasoline were heated in a reflux condenser for one hour with 6 ml. of solution No. 1. The gasoline acquired an orange-yellow color. Losses amounted to 0.35 g., and as in the previous experiment, the chlorate was incompletely utilized. During the distillation 20.41 g. of gasoline were obtained. The gasoline had an endpoint of 170°C., a sulphur content of 0.056, a chlorine content of 0.07 percent, and its specific gravity was 0.800. In addition, 2.04 g. of polymers boiling at 170-200°C. and containing 0.463 percent sulphur and 0.26 percent chlorine were obtained. The yield of gasoline amounted to 86.2 percent and the refining was 85 percent efficient.

The gasoline turned slightly yellow in the doctor test and the total sulphur content was 0.146 percent before the fractionation into gasoline and polymers. Thus, 60.5 percent of the sulphur content was converted into soluble sulphates, 24.5 percent was separated by distillation as the result of polymerization, and only 15 percent of the original sulphur remained in the refined gasoline. It should be noted, however, that the gasoline used already had been treated at room temperature and its sulphur content decreased from 0.427 to 0.369 percent.

The consumption of the chlorate amounted to 2.12 percent and as already mentioned, the chlorate was not completely utilized. Assuming that the cost of one ton of chlorate is 400 rubles (a ruble is approximately 50 cents), the cost of treating one ton of gasoline will be 8.50 rubles. The cost of the 15 percent sulphuric acid used (49.5 kg. per ton of gasoline) may be disregarded as it is a waste product or can easily be regenerated.

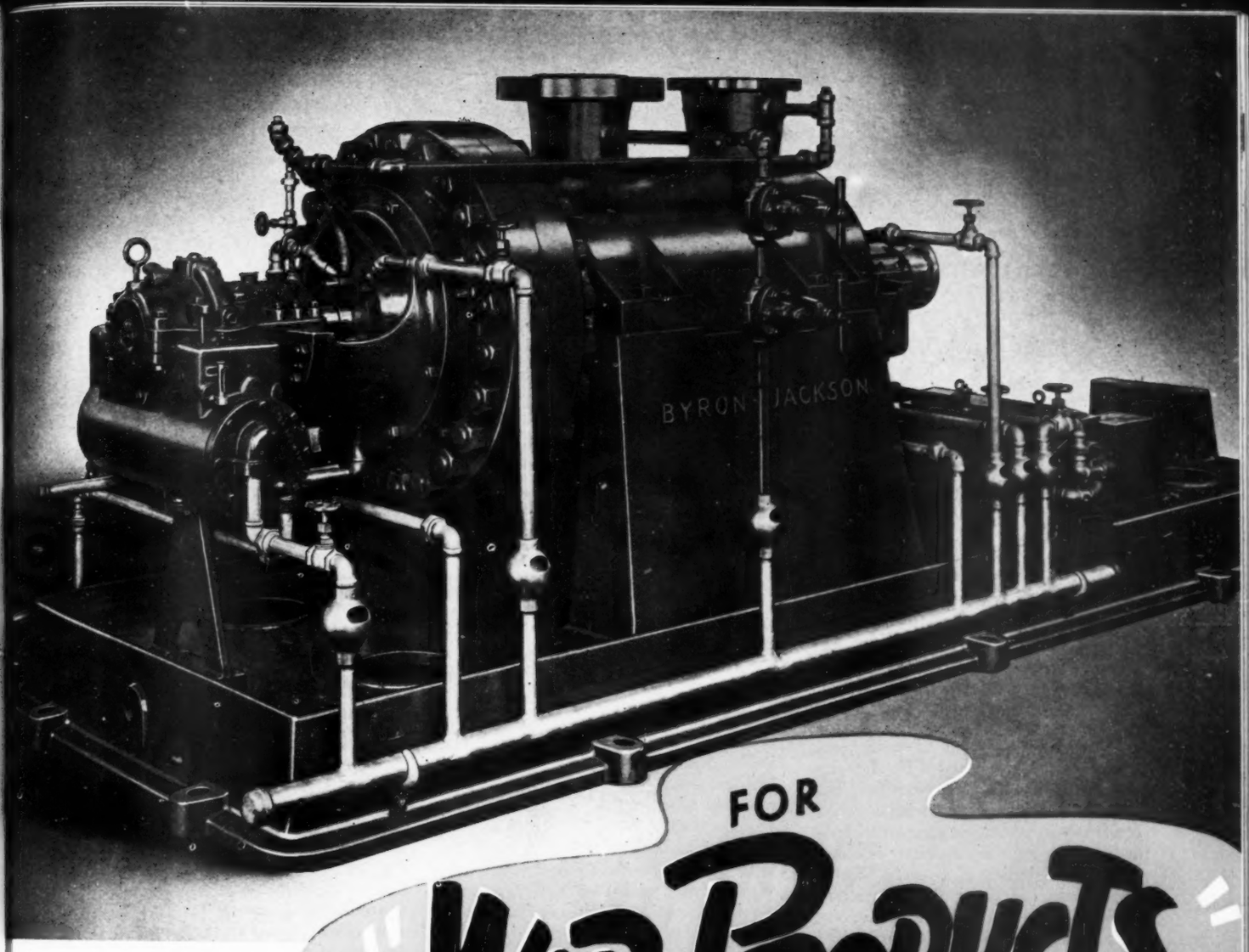
Second experiment. A light fraction of the Chusovo gasoline boiling at 40-100°C. and amounting to 21.1 g. was heated in a reflux condenser for one hour with 6 ml. of solution No. 1. As in the previous experiment, the gasoline acquired a distinctly yellow color and the mercaptan odor disappeared completely. The losses amounted to 1.2

(Continued on Page 167)

[4]Only the most typical experiments are discussed. In all, 33 experiments, 97 sulphur determinations, and 92 chlorine determinations were made, some of which were repeated.

TABLE 4
Properties of gasoline fractions

Fraction boiling at °C.	Yield percent by volume	d_{20}	Chlorine, percent	Sulphur, percent	Weight percent of raw material	Total yield in percent	Percent sulphur at given temperature
65–100	11.0	0.743	0.0079	0.0348	11.3	11.3	0.0301
100–150	52.3	0.784	0.0012	0.0881	48.7	60	0.0771
150–200	31.1	0.823	0.0011	0.339	30.6	90.6	0.165
200–224	5.6	0.786	0.0047	1.013	5.0	95.6	0.211
	100.0					100.0	0.427



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In making synthetic rubber, high octane gasoline and other War Products, Byron Jackson Pumps meet the exacting requirements of the Refining and Chemical Process Industries. . . . Also for hydraulic press service in the manufacture of armament, Byron Jackson Pumps now make possible operations never before feasible. For example, 3 units of the type pictured above are delivering 1,500 g.p.m. at 6,000 psi. . . . Ask for details to solve *your* War Products pumping problems.

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Established 1872

BYRON JACKSON

CENTRIFUGAL PUMPS FOR EVERY SERVICE

(Continued from Page 164)

g. The gasoline was washed with caustic after a titration determination showed 0.4 ml. of KOH with a liter of 0.00547 g. per cc. was needed for 5 ml. of gasoline. In the distillation up to 145°C. 24.5 ml. of gasoline with a specific gravity of 0.7508, a sulphur content of 0.050 percent and a chlorine content of 0.038 percent was obtained. The total yield of gasoline was 93 percent and the efficiency of refining was 83.5 percent.

The cost of reagents per ton of gasoline was:

Chlorate	22.1 kg. per ton	8.84 rubles
Sulphuric acid	49.2 kg. per ton	1.97 rubles
Caustic	0.57 kg. per ton	0.06 ruble
Total cost of reagents		10.87 rubles

As was shown by preliminary experiments, the treatment of sulphur containing gasolines with solutions of chlorates at ordinary temperatures was not satisfactory. Using the same solutions at the boiling point of the gasoline about 84 percent of the sulphur can be removed; there are some disadvantages, of course, to the heating of gasolines.

The following method of batch treatment of gasolines is recommended. The still should be equipped with a reflux condenser in addition to the usual condenser. The regular condenser is closed in at the beginning of a run so heating and refining of the gasoline can take place. The condenser then is opened and the preheated gasoline distilled over. The advantage of this is that it eliminates the use of strong sulphuric acid.

Third experiment. 53.9 grams of Chusovo gasoline boiling at 100-225°C. was treated in an agitator for 20 minutes with 10 ml. of solution No. 2. The oxidizing solution was introduced into the agitator in drops during the first 5 minutes. The reaction temperature was 18-21°C. The gasoline, as well as the bottoms acquired a brownish color and had a strong odor resembling that of naphthalene. Losses as a result of evaporation amounted to 1.21 g. The bottoms turned slightly bluish in color with diphenylamine, which indicated a slight excess of chlorate. The gasoline was washed twice with 5 ml. batches of 6° Bé caustic. To saponify the chlorides the gasoline was boiled for one hour with 10 ml. of caustic but this operation later was found to be unnecessary. The purified gasoline then was fractionated into four fractions, none of which was affected by the doctor solution. The properties of the fractions are given in Table 3.

The data given in Table 3 show that the content of sulphur decreased to a particularly great extent in the first and medium fractions, whereas the sulphur content in the last fraction increased above the original content of 0.427 percent. Evidently part of the mercaptans had not been converted into the soluble state but were oxidized into high boiling point disulphides that could be separated by distillation.

Fourth experiment. On comparing the first part of the first experiment, i.e., the unsatisfactory purification of the gasoline by chlorates in the presence of a 15 percent sulphuric acid, with the third experiment where the same amount of chlorate under identical conditions but in the presence of a 75 percent sulphuric acid gave very satisfactory results, the importance of the concentration of the acid is quite obvious.

There remains to be proved, however, that the amount of acid is of no importance as the acid does not partake in the oxidation process but is merely a needed medium and the degree of refining depends only upon the amount of chlorate used. To prove this statement, the same amount of gasoline, i.e., 59.5 g. and the same amount of acid but only about 25 percent as much chlorate (0.252 g.) was used in the fourth experiment. The treatment also was continued for 20 minutes. The gasoline acquired a yellowish color and the bottoms turned brownish-red. The gasoline had a pronounced odor resembling that of naphthalene. Loss due to evaporation was 0.93 g. The bottoms did not turn blue with diphenylamine. The gasoline was washed twice with 15 ml. of water and 2 ml. of caustic, which was found satisfactory because, after washing, the caustic turned litmus paper blue.

Refined gasoline was fractionated into four fractions and it was found that the fraction boiling at 65-100°C. passed the doctor test whereas the other fractions did not and gave an orange to red color to the gasoline. It was found also that the fractions were free of SO_2 (neutral reaction with methyl orange), which could have separated in the decomposition of sulphuric acid esters. The properties of the fractions are given in Table 4. It is evident from the table that in the given experiment the effect of refining was low as a result of the insufficient amount of chlorate (0.5 percent) used. This is proof that in the cases investigated, chlorate and not sulphuric acid is the active ingredient.

From the data shown in the seventh and eighth columns of Tables 3 and 4, the graph, Fig. 1, was prepared to show graphically the relation between the yield of gasoline and the sulphur content for different consumptions of the chlorate. The graph shows the curve for zero consumption of chlorate and for consumptions of 5, and 18 kg. per ton of refined gasoline. By graphical interpolation the curves for the consumption of 2.5 and 10 kg. per ton of gasoline were determined. The shaded area indicates gasoline with a sulphur content of less than 0.3 percent. In the square at the bottom of the shaded area is the area of gasoline having a sulphur content not exceeding 0.1 percent. Both areas are delimited on the left by the line of minimum yield, i.e., 80 percent. The 5 kg. curve is the boundary between the areas of active and inactive sulphur.

Almost all problems arising in the application of chlorates to the refining of gasoline may be solved by using the graph. Thus, for example, the intersection of the line of minimum yield with the zero line gives the reading of 0.215 on the ordinate, indicating that by means of a simple distillation a yield of 80 percent gasoline may be obtained with an active sulphur content of 0.215 percent. If 10 kg. (1 percent) of chlorate are used in the refining process, then for the same yield, a gasoline containing 0.07 percent sulphur will be obtained. Using 18 kg. of chlorate (1.8 percent), 80 percent gasoline containing only 0.025 percent sulphur will be obtained.

The sulphur content of the gasolines can be ascertained on the basis of the yield of gasoline and the desired consumption of chlorate. Thus, in the case of experiment No. 4, for a gasoline yield of 85 percent, 0.145 percent of sulphur will be present in the gasoline; in the case of experiment No. 3, the sulphur content will be only 0.055 percent for a gasoline yield of 94 percent. The amount of chlorate required can be ascertained for the desired sulphur content and yield of gasoline. If, for example, for an 85 percent yield of gasoline the desired sulphur content is 0.1 percent, then 8 kg. of chlorate will be required per ton of gasoline, or $8 \times 0.85 = 6.8$ kg. per ton of the refined gasoline.

Conclusions

(1) The application of aqueous or slightly acidic solutions of chlorates is not accompanied by any fire or explosion hazards.

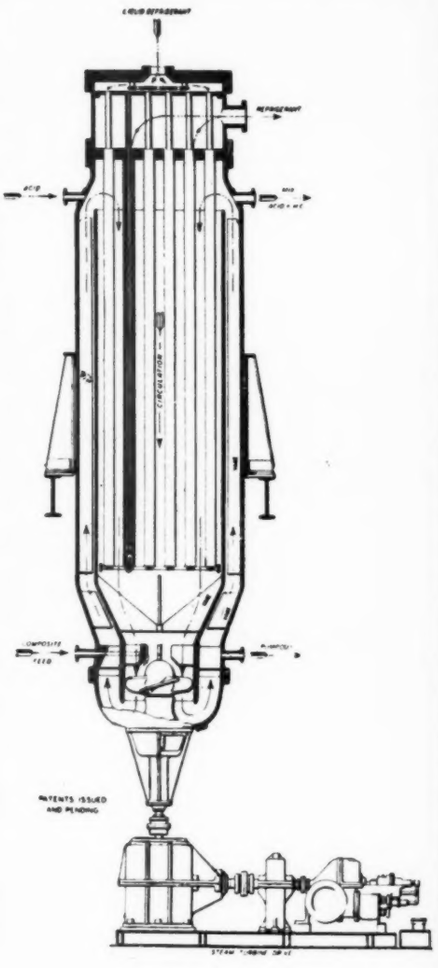
(2) The use of chlorates in the refining of gasoline, insofar as their cost and effectiveness are concerned, is to be preferred to almost all existing methods including the hypochlorite, aluminum chloride, and catalytic hydrogenation methods at medium pressures.

(3) Chlorate refining is inferior in its effectiveness to the catalytic hydrogenation process at elevated pressures but it is a considerably cheaper and simpler process.

(4) The chlorate treatment gives very good results when refining straight-run gasoline and satisfactory results with cracked gasolines.

☆ ☆ ☆

STRATCO ALKYLATE



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Result:

MORE FIGHTING FUEL

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Expanded Refinery Aids War Effort in California

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☆ **New construction results in greater output of needed refinery products**

by Wallace A. Sawdon

Pacific Coast and Foreign Editor

A refinery, recently expanded and designed to help meet the needs of a vital area in California, is utilizing to greatest advantage low-gravity, sulphur-bearing crude oil. Although the main product of this plant during the greater part of the year is road oil and asphalt, it consistently produces approximately 14 percent of high-grade gasoline and can proportion the lower ends to fuel oil and asphalt manufacture as demand necessitates.

The plant is owned and operated by the Bell Oil and Refining Company, which took over the nucleus of the present refinery a little more than three years ago. At that time it seemed impossible to make the plant a paying operation because of the character of the only crude oil available and the difficulty of distributing the refined products. The new organization, however, had taken all the difficulties into consideration and had made definite plans to meet the problems by redesigning the plant to obtain greater flexibility in manufacture, by expanding it to make the operation profitable and by providing for transportation of products by leasing tank cars. A pipe line was also procured and at the present time all crude oil into the refinery is supplied by this pipe line, except for a small amount trucked in from another field.

Although the redesign and expansion program of the refinery was instituted to meet peace-time demands, its location has made it of considerable importance in the war effort. Its gasoline is being made to Army specifications with an octane rating of 80 and above and is being trucked to a number of army camps in the vicinity. This eliminates the long haul from more distant large refineries and thus aids in the reduction of transportation, which is a vital factor at the present time. Gasoline to the Army is hauled in the company's own tank trucks. The remainder of the gasoline being manufactured is sold to marketing companies operating in the surrounding territory and thus also aids in reducing the transportation problem by eliminating tank car shipments or other long hauls from more distant points. Gasoline supplied to marketing companies is hauled by the marketing company trucks, which pick up the product at the refinery.

Until recently the asphaltic products were made to 18 standard specifications and to meet any other specifications requested by the purchaser. These specifications have now been reduced to eight but asphalt can be supplied to meet any demands that may be made, provided they are permissible under war-time regulations.

Most of the asphalt processed and pumped to storage is 200-300 penetration. The storage capacity of the one penetration product is 111,500 bbl. and other storage is provided for asphalt of lower penetration.

Shipments of asphalt are made by tank cars and, although the bulk of this product goes to the western states, shipments are made to as far east as Texas. During the last few months the asphalt from this plant has averaged 12.5 percent of the total manufactured in the western states. Due to the provisions made by the Bell Oil and Refining Company in leasing tank cars there have been no difficulties encountered in making shipments. At the present time there are approximately 200 tank cars in the company's service and most of the shipments are made in these cars.

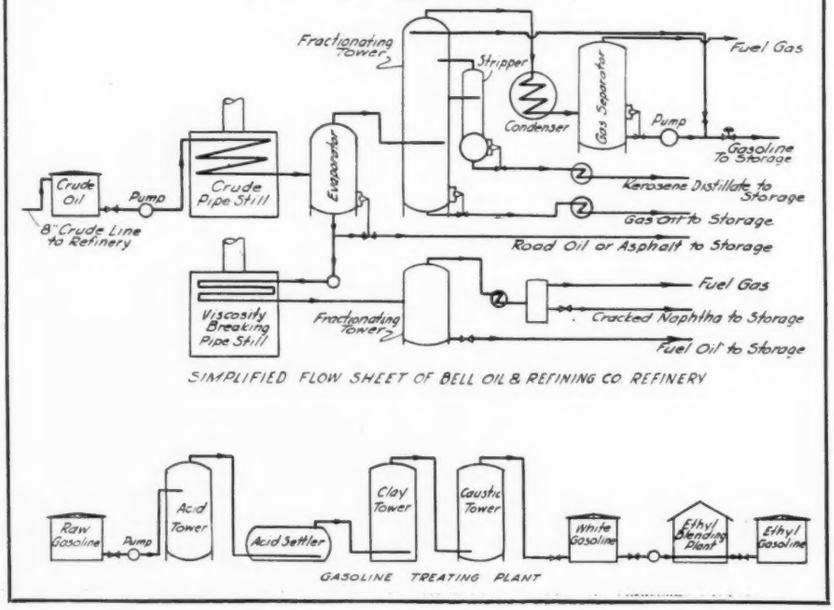
The loading rack provides for the loading of 12 cars with asphaltic products at each switching. That is, if there are four switches, 48 cars can be loaded in one day. Similar facilities exist for loading trucks.

Weather conditions rarely affect the market because shipments of asphalt in winter are to the warm dry southern states and to coastal areas when the temperature is regular and conditions are constantly dry. Year-round operation is assured because of fuel oil, roofing flux, and low penetration asphalt contracts.

The fuel oil being processed from sulphur-bearing crude oil carries a maximum content of 5 percent sulphur. Contrary to earlier conceptions, how-

(Continued on Page 171)

Fig. 1. Flow diagram of refinery



(Continued from Page 168)

ever, the fuel has been found highly satisfactory as evident from continual sales in comparatively large volume to railroads and mines in the western states for steam generation. The fuel oil is supplied in several grades and production of this commodity approximates 1500 bbl. per day. The specifications of the two principal grades are given in Table 1.

TABLE 1
Fuel oil specifications

	Heavy fuel	Light fuel
Gravity, °A.P.I.	10–12	14–16
Pinsky-Martin flash point	150 plus	150 plus
Saybolt-Furol viscosity at 122° F.	250–300	100–150
B.S. and water, maximum	1 percent	1 percent
Pour point, maximum	50	30
Maximum sulphur	5 percent	5 percent
B.t.u., minimum	18,000	18,000

Operations of the refining company are under the direction of Jos. H. Gilliland, president and general manager; distribution is handled by Wm. F. Lyte, vice-president in charge of sales. Norman F. Tyacke is superintendent of the refinery and L. A. Davis is treasurer. Employee relationship is excellent. Included among the reasons for this condition is a profit-sharing plan for all employees and a bonus of 5 percent of wages earned during the fiscal year period ending December 15, the bonus being paid the day before Christmas. Practically all employees are experienced refining men who are not subject to the draft so this factor, combined with the profit-sharing inducement, places the operation in a very stable condition at a time when labor shortage generally presents a serious problem.

The Refinery

The capacity of the refinery is 7000 bbl. of crude oil per day and, although the actual throughput has been less than 4000 bbl. per day to date, it is hoped that with the recent completion of the refinery a crude supply much closer to the capacity of the plant will be available. The last installation to be completed was the rebuilding of the viscosity breaking pipe still.

Most of the crude oil is that transported to the plant through the 8-in. line as mentioned. This crude ranges in gravity from 13° to 17° A.P.I., but augmented by some 20° A.P.I. crude oil transported by truck from a nearby oil field, the average gravity of crude through the refinery approximates 15° A.P.I.

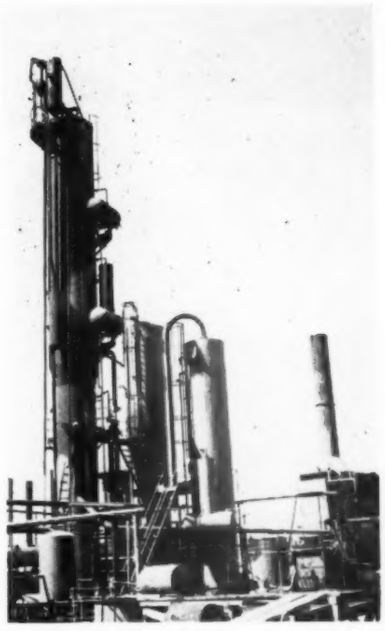
As indicated by the simplified flow sheet given in Fig. 1, the crude is pumped through the crude oil pipestill to the evaporator. The overhead from the evaporator goes to the fractionating tower for fractionation of the upper ends. The lower ends can then be utilized in any proportion desired for the manufacture of road oil and asphalt or fuel oil.

The overhead from the fractionating tower passes through a condenser and then through a gas separator where the fuel gas is taken off, the gasoline going to storage. The lower gasoline fractions are taken off from near the top of the tower and go direct to storage in combination with the gasoline from the gas separator. The kerosine distillate, after passing through the stripper, goes to storage, and the bottoms, consisting of gas oil, also goes to storage.

The lower ends from the evaporator then either go to storage for stock for making asphalt or road oil or are processed for naphtha and fuel oil. Any amount of these lower ends can be pumped through the viscosity breaking pipestill and then sent to the second fractionating tower. Here the overhead passes through a condenser, then through a gas separator where the fuel gas is taken off and the naphtha pumped to storage. The bottoms from the tower go to storage as fuel oil.

The flow sheet of the gasoline treating plant given in Fig. 1 indicates the process used converting the raw gasoline to Army specifications.

The products below gasoline are not desulphurized and, as the crude is an asphaltic base oil, no lubricating oil is processed. With the various products in storage the asphalt or fuel oil can be blended to meet the specifications called for and the blending methods employed provide for close control of the product shipped.



Distillation units with crude oil pipestill to right

The road oil and asphalt pumped to storage from the bottom of the evaporator is mainly 200-300 penetration. Lower penetration cuts, controlled by temperature in the crude oil pipestill, are taken when desired and run to separate storage. Higher penetration cuts can be taken off direct by heat control or by blending with distillates in storage or by a combination of both methods.

Fuel oil is being processed by passing the bottoms from the evaporator through the viscosity-breaking pipestill. When it is desired, if extra distillates are in storage, the residuum is cut back with distillates to manufacture fuel oil.

All fuel gas taken off the distillation units is utilized for plant operation. This does not meet requirements, however, and from 1.5 to 2.0 million cu. ft. per day is purchased.

Automatic controls are used throughout the refining operations. Testing is done in a laboratory situated close to the operation and management offices. This laboratory has been newly equipped and is capable of running tests on all products.

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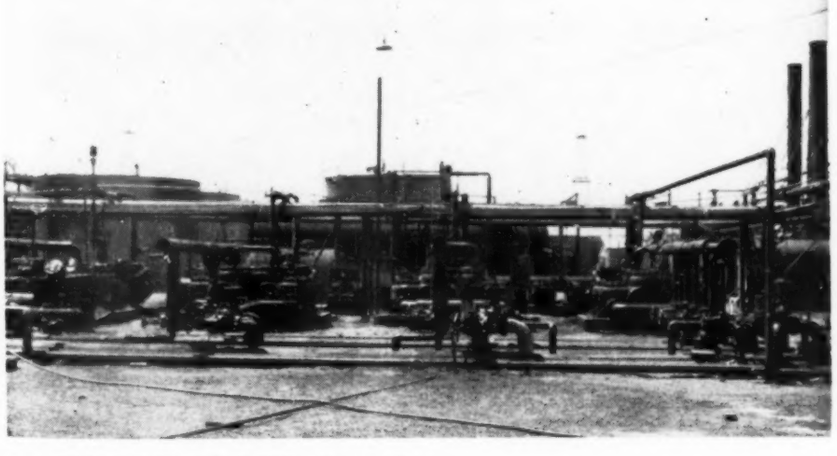
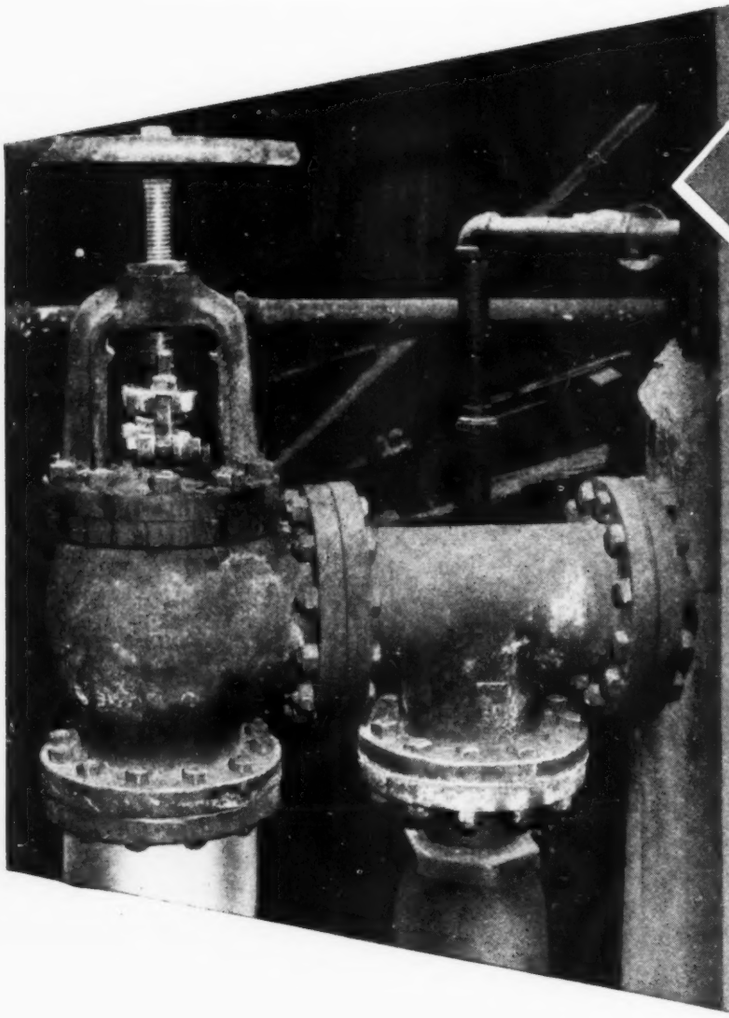


Pumps and manifolds

This is the 2ND in a series of messages



2a THE PROBLEM

Insulation of an 8" T and valve.

2b THE SOLUTION

Application of Unibestos, the sectional pipe covering. Unibestos is available in Standard material for temperatures up to 750°; Super, with a temperature limit of 1200°; Combination, with a temperature limit of 1200°. These temperature limits permit the use of one material at maximum efficiency for a wide range of purposes. Unibestos is available in half sections up to 30" pipe diameter and from 32" to 60" in quadrants from ¾" to 5" in thickness. Standard and Super Unibestos are available in single layer construction with provision for expansion in piping, where required.

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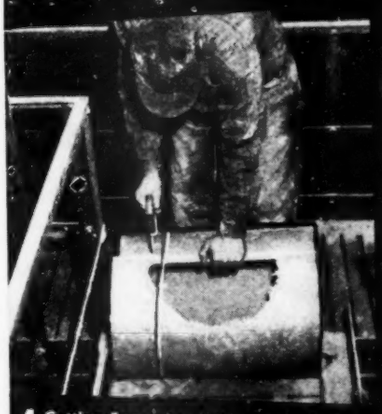
DEALING WITH THE PROBLEMS IN HEAT INSULATION FACED BY ENGINEERS AND SOLVED BY USING UNIBESTOS

1 Cutting Unibestos, the sectional pipe covering, to cover the body of the 8" T.

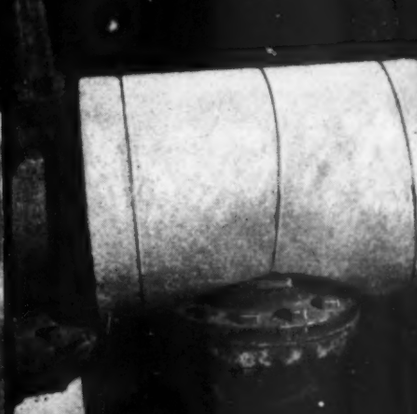
2 Fitting Unibestos to the T.

3 Wiring Unibestos in place.

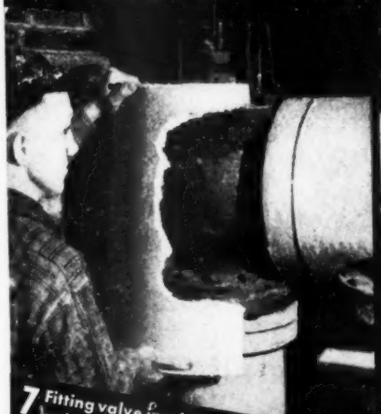


4 Cutting flange insulation for the T. Unibestos cuts clean with ordinary tools.

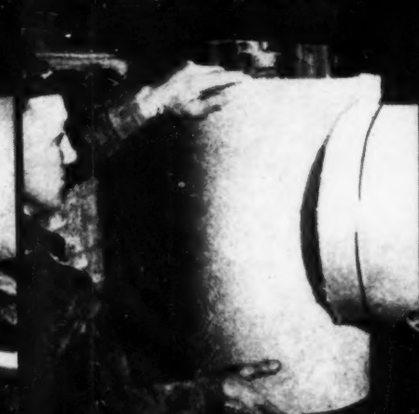
5 Applying flange insulation.



6 Flange insulation wired in place.



7 Fitting valve insulation. Collar of Standard covering under lower flange brings adjacent pipe covering to proper level.



8 Valve insulation fitted in place.

9 Completed, and ready for finish to be applied. Unibestos can be removed and reapplied easily without damage to material or loss of efficiency.

UNARCO

Insulation for Marine, Railroad, Aviation and Industrial Use

Construction of Refinery Boiler Settings

PETROLEUM ENGINEER Exclusive Feature

☆ Monolithic-type settings installed in plant at low cost—New features incorporated

by Jesse T. Browning

Assistant Superintendent, Longview, Texas, Refinery,
The Skelly Oil Company

THE management of The Skelly Oil Company's Longview, Texas, refinery recently was confronted with the problem of rebuilding the settings on three Heine 300-hp. cross-drum boilers. Consideration was given to rebuilding the walls as they were using fire brick lining and common brick outer walls. After soliciting bids from refractory contractors on the basis of a turnkey job it was decided that the cost in this instance would be prohibitive. As an alternative it was decided to attempt to employ brick layers and provide proper supervision and engineering. This idea had to be abandoned because of the acute shortage of bricklayers in the area brought about by defense jobs that were in progress. After considerable study the decision was reached that a material should be used that would not require skilled workmen, this material being a fire brick lining and featherlite aggregate in high early Portland cement for the outer walls.

Salvage and Design

Obviously, the first step was to tear down the old setting and salvage all usable firebrick and prepare them for the new construction. After the old material was removed and the setting foundation could be examined it was noted that considerable damage had been done to the concrete by excessive heat. It was felt that this condition was largely responsible for the fact that the old walls had cracked. At this point it was decided to make provisions for an air-cooled floor in order to dissipate this heat and keep the foundation from deteriorating. Thus preheated air would be supplied to the burners, which was considered advantageous from an economic point of view. To do this it was necessary to provide for eight air ducts in the foundation at each end of the boiler, leaving the construction of the floor proper until the termination of the job. At the back of the boiler an intake wind box was constructed approximately 72 in. long by 24 in. wide by 18 in. deep. At the front of the boiler a similar wind box was constructed, and into it was built an air control damper. The burners were enclosed in a light steel jacket.

JESSE T. BROWNING

—graduated from Central State College, Edmond, Oklahoma, in 1932 with a B.S. degree—Taught in the high schools of Oklahoma for three years and was then employed by The Skelly Oil Company as solvent fractionator operator at Lyman, Oklahoma—Other work included assignments in connection with natural gasoline plant operations at Fairfax, Oklahoma, Burkburnett, Texas, and Wynona, Oklahoma—He was plant superintendent at Wynona—In 1941 he was assigned to his present position as assistant superintendent at the Longview, Texas, refinery of The Skelly Oil Company.

Construction

In building the furnace walls the firebrick lining was completed before the concrete outer walls were poured. In this construction 13½-in. walls were erected, using salvaged firebrick laid up by immersing them in high temperature bonding mortar. In the wall were placed 9-in. by 9-in. by 1½-in. anchor tile and ½-in. bolts were inserted. Sleeves made of 1-in. pipe were placed around these bolts, in event at some future date, work would need to be done on the furnace lining. Also, to make repairs easier on the lining and eliminate distortion by expansion, provisions were made for three expansion joints in the side walls and two in the back wall. These joints were constructed with an opening approximately 1 in. wide, which was filled with expansion joint compound as the job progressed.

After the lining was completed the outside was coated with a layer of long fiber asbestos troweled to a thickness of approximately ¼ in. This was done to keep the concrete outside wall from adhering to the lining so that reasonable movement caused by expansion would be allowed and also additional insulating quality to the construction would be provided.

At this point reinforcing wire was stretched in the concrete wall. For this material 10-gage woven wire was preferred, but as this material was not available, barbed wire was used, being

tied in such a manner that the vertical strands would cross the horizontal strands on 6-in. centers.

Concrete and Forms

In constructing the forms, it was elected to use 2-in. lumber to eliminate the possibility of bulging during the time the form was being poured and for the further reason that substantial forms would last for the duration of the three jobs. These forms were so constructed that it would be necessary to move them upward twice on the side walls and once on the back wall.

In the construction of the outside walls a light-weight aggregate was used in proportions of six parts to one of high early Portland cement. This aggregate was selected for various reasons, the most important being low heat conductivity, strength, and low unit weight. This particular aggregate was produced by the burning of shale under intense heat, which in turn caused each particle to possess countless small air cells. In construction the resultant product is a series of trapped air cells, conducive to good insulation. Chemical analysis of this aggregate is as follows:

Loss on ignition	0.70
Silica (SiO_2)	94.83
Iron oxide and alumina	3.83
Calcium oxide	0.40
Sulphate (as SO_3)	0.12
Magnesium oxide	0.01
Chlorides	none
	99.89

Volatile matter at 105°C., 0.06.

Thermal insulation factor K point, 0.148.

Fusion point, 2000 to 2500°F.

Approximate weight of concrete per cu. ft., 80 lb.

Aggregate size range from fines to ¾ in. in diameter.

This material was produced through accident by refuse from coal mines catching fire and bloating shale that was present in the clum piles.

Setting and Pouring Forms

In setting the forms care was exercised not to include totally any of the H-beam supports for fear trouble would be encountered in buckling under weight and heat after the boiler was put into service. To eliminate this possibility as much area was left exposed to to the atmosphere as possible, which in the case of the stack breeching was one flat side and on the boiler supports one flat side and one hollowed side.

Considerable care was taken in mixing the concrete. The proper amount of water is most important. This amount will vary according to the dampness of the aggregate. The proper amount will range from 8 to 12 gal. per sack of cement. The mixed concrete should be of such consistency that it will puddle slightly when placed in the forms. In mixing it is recommended that approximately one-half the water be put in the mixer first and then the aggregate, adding the rest of the water and allowing it to turn for at least two minutes before putting in the cement. This is done to prevent the aggregate from pulling the cement into the small air pockets and thereby leaving the mixture without a bonding agent.

After each successive run when the forms are removed it is well to wet the concrete down thoroughly, about twice each day, so that proper curing will occur. About ten days after the walls are completed it is satisfactory to put the boiler into service.

By using this type of construction our company saved one-third to one-half on its labor bill and made a substantial saving in the cost of materials as compared to what it would have cost to replace the walls of firebrick with a common brick outer wall. It is believed that this is a much better setting because of the steel-reinforced wall constructed of material of good insulating qualities. Very little trouble is expected to be encountered with cracked walls, which permits infiltration of air and causes loss of boiler efficiency.

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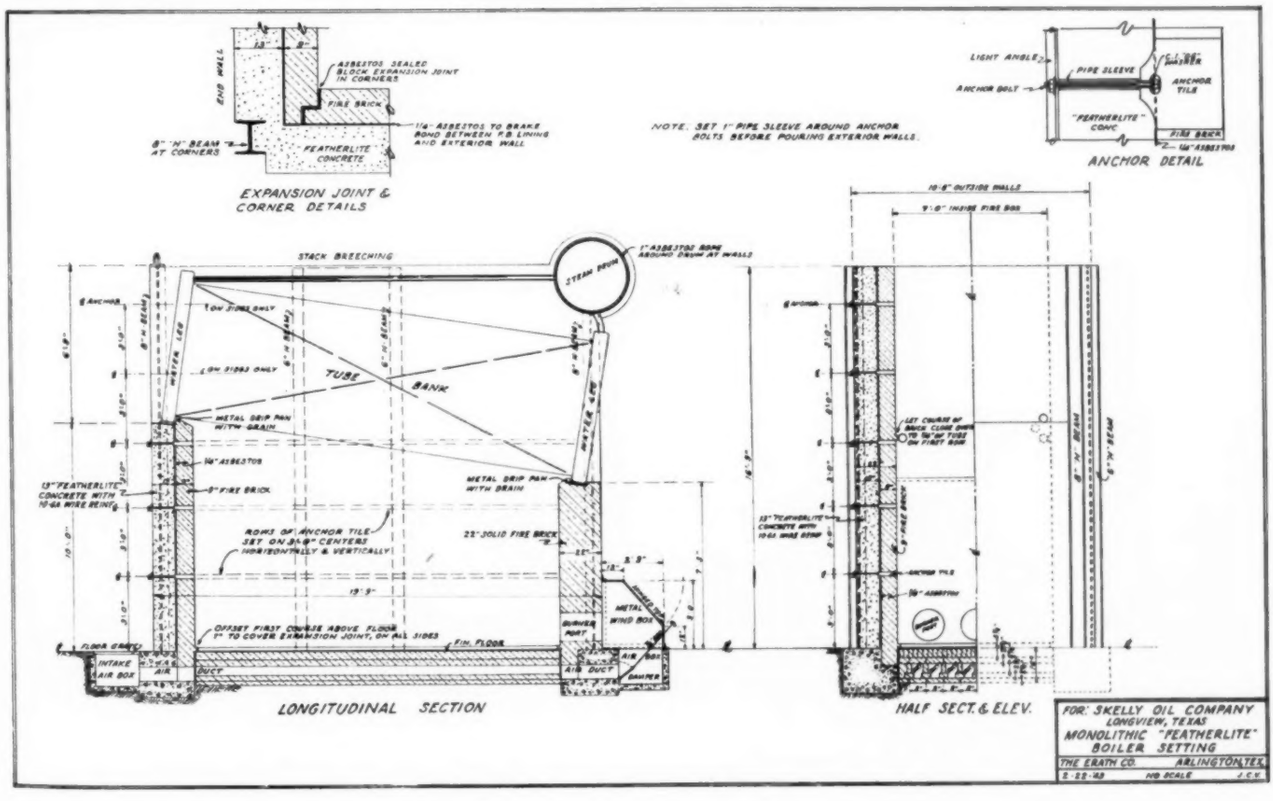
Plan of monolithic-type boiler setting



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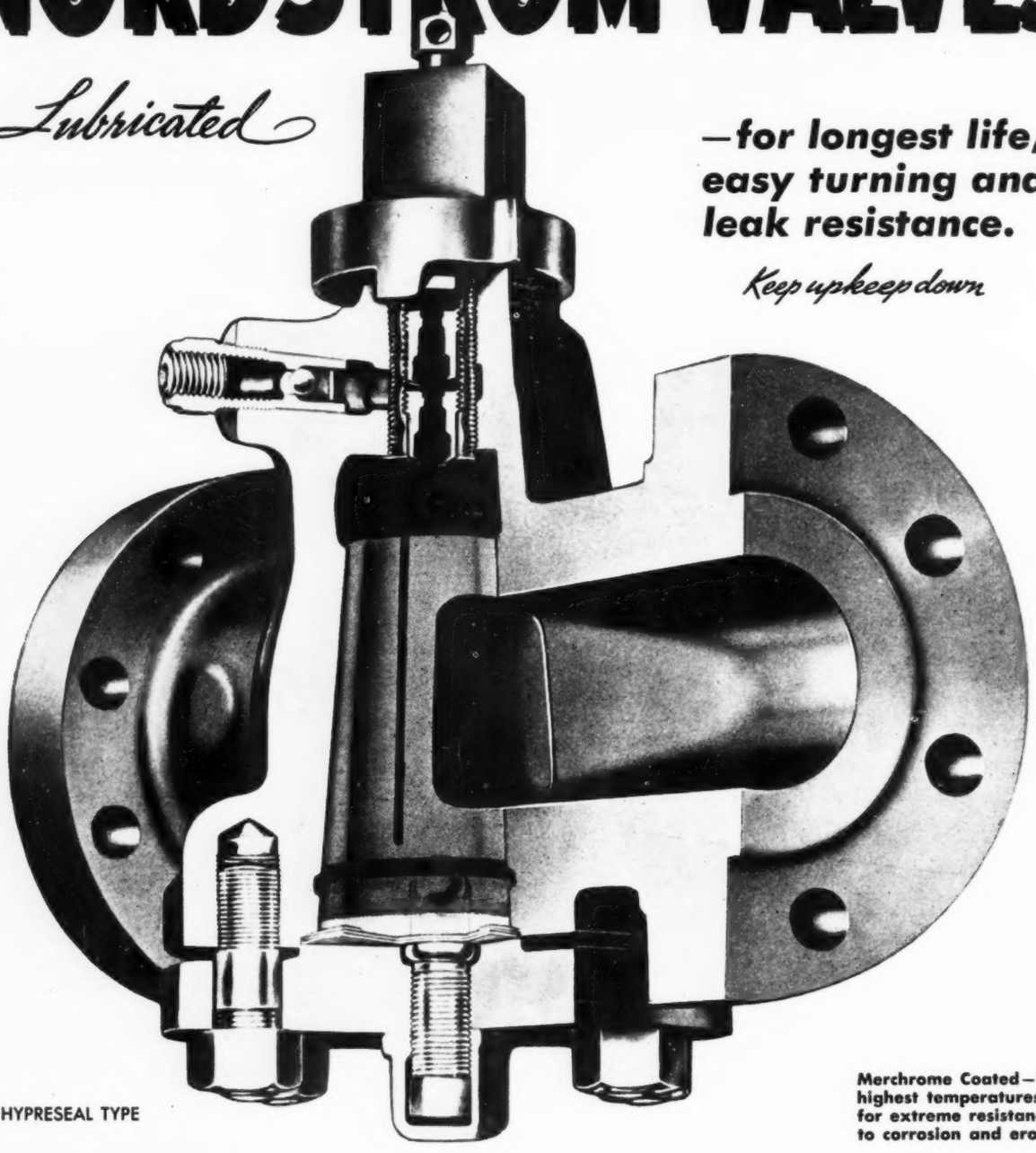

HYPRESEAL TYPE

Merchrome Coated—for highest temperatures, and for extreme resistance to corrosion and erosion.

FIG. 1925

FIG. 1985

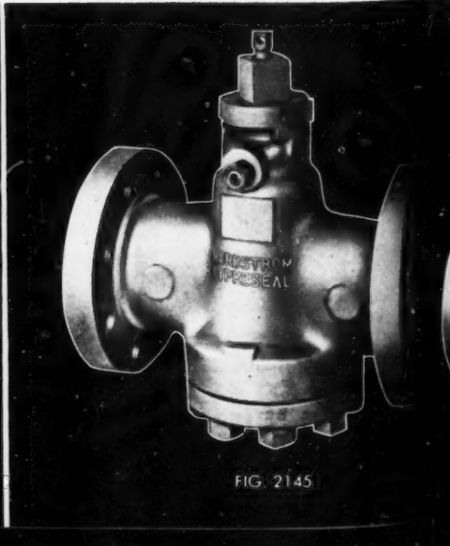

FIG. 2145

....Bearing
the burden of control
on the *toughest* lines in Refineries

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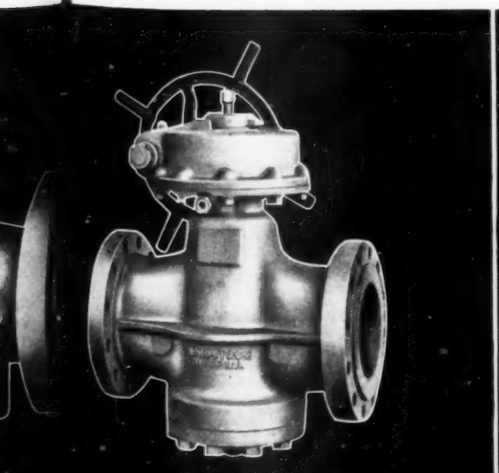


FIG. 2149

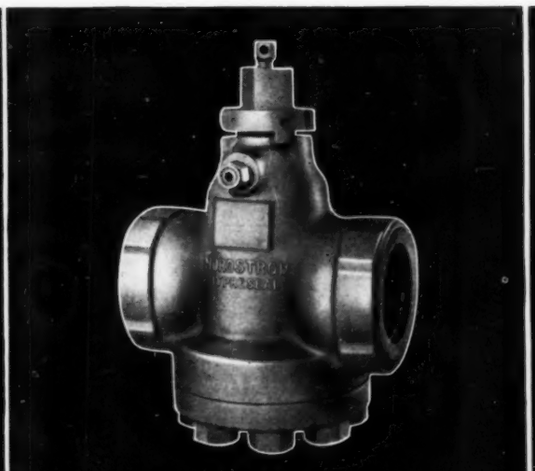


FIG. 2344

FIG. 6405

New Process Increases Recovery of High-Melting-Point Wax

PETROLEUM ENGINEER Exclusive Feature

☆ **Development of latest commercial process permits refining of crude wax to produce oil-free wax**

by John Salmond

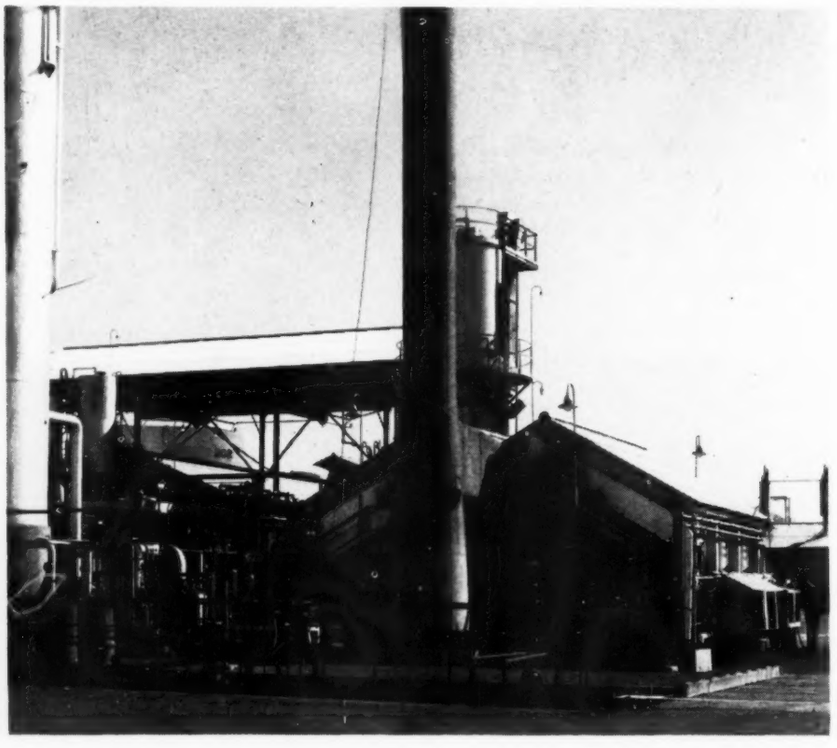
Supervisor of Refining Operations, Union Oil Company of California

MIXED-BASE crudes supply a large proportion of the present-day paraffin-type lubricating oil being produced by various combinations of distillation, solvent extraction, and dewaxing processes. Refining methods obviously differ; but regardless of the particular order followed in performing different stages or of the specific solvent extraction and dewaxing process used, there results from the refining of the mixed-base crudes a production of crude wax composed of high-melting-point wax and high-viscosity oil. The conventional sweating process will not refine this crude wax to yield oil-free wax and, until the last few years, there has been no satisfactory process for recovering this potentially valuable material. Realizing the high market value of the high-melting-point, crystalline-type wax that is available from the crude wax, Union Oil Company has developed a process for its recovery and is now operating a recently designed plant at its refinery at Oleum, California.

So far as is known, there are only two other commercial processes designed to produce fully refined waxes from such crude-wax production. The first of these appears to be most applicable to the deoiling of the lower-melting-point waxes; the second seems to be applicable to the deoiling of crude waxes having a fairly wide range of melting points and oil contents. The Union Oil Company process[1] is applicable to the deoiling of any crystalline-type wax and was developed by Union as a result of experiments beginning in 1936. Although the process is now being employed only in a plant designed specifically for its utilization, it permits modifications that provide for its incorporation into existing refining operations without extensive construction. Adaptations to existing plants can thus be made for the production of greater quantities of much-needed wax and high-viscosity-index oil.

[1]U. S. Patent No. 2,229,658.

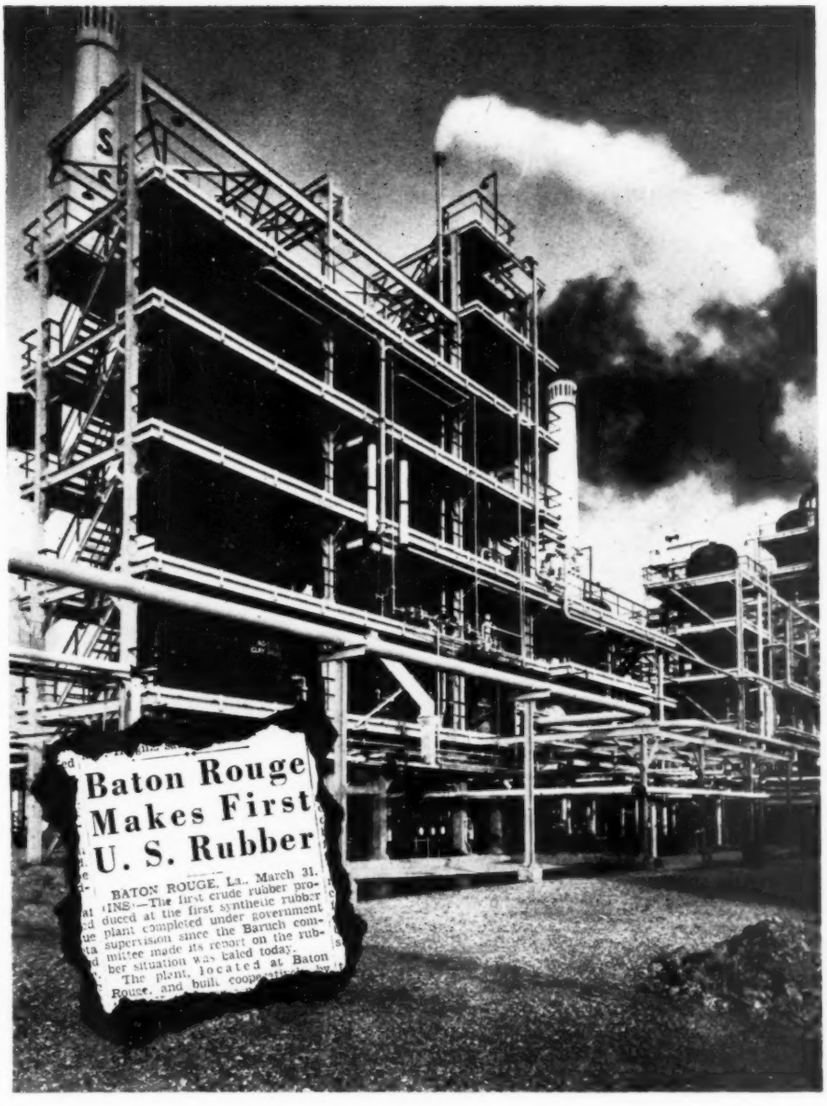
JOHN SALMOND



General view of wax plant

Development Work

Experimental observations indicated that, regardless of its melting point and contrary to the belief of some, a straight-chain paraffin wax separates in an oil-free condition when crystallized from the oil with which it is normally associated.[1] Utilizing this discovery, it appeared possible to devise a relatively simple deoiling method that would be applicable to any crystalline wax—no matter what its melting point might be. This conclusion being verified, it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was found that the solidification of such waxes upon cooling to atmospheric temperature could be prevented by continuous stirring during the cooling operation and that, under such conditions, the wax crystals separating from the oil did not interlock to form a rigid structure. Smooth, semi-fluid slurries or plastic mixtures of wax crystals in oil were thus obtained, the relative fluidity of the slurries varying with the viscosity of the oil and the amount present in the crude wax. Slurries having certain desired fluidities could, however, be obtained from any crude wax by the addition of oil, either before being cooled or during the cooling operation.

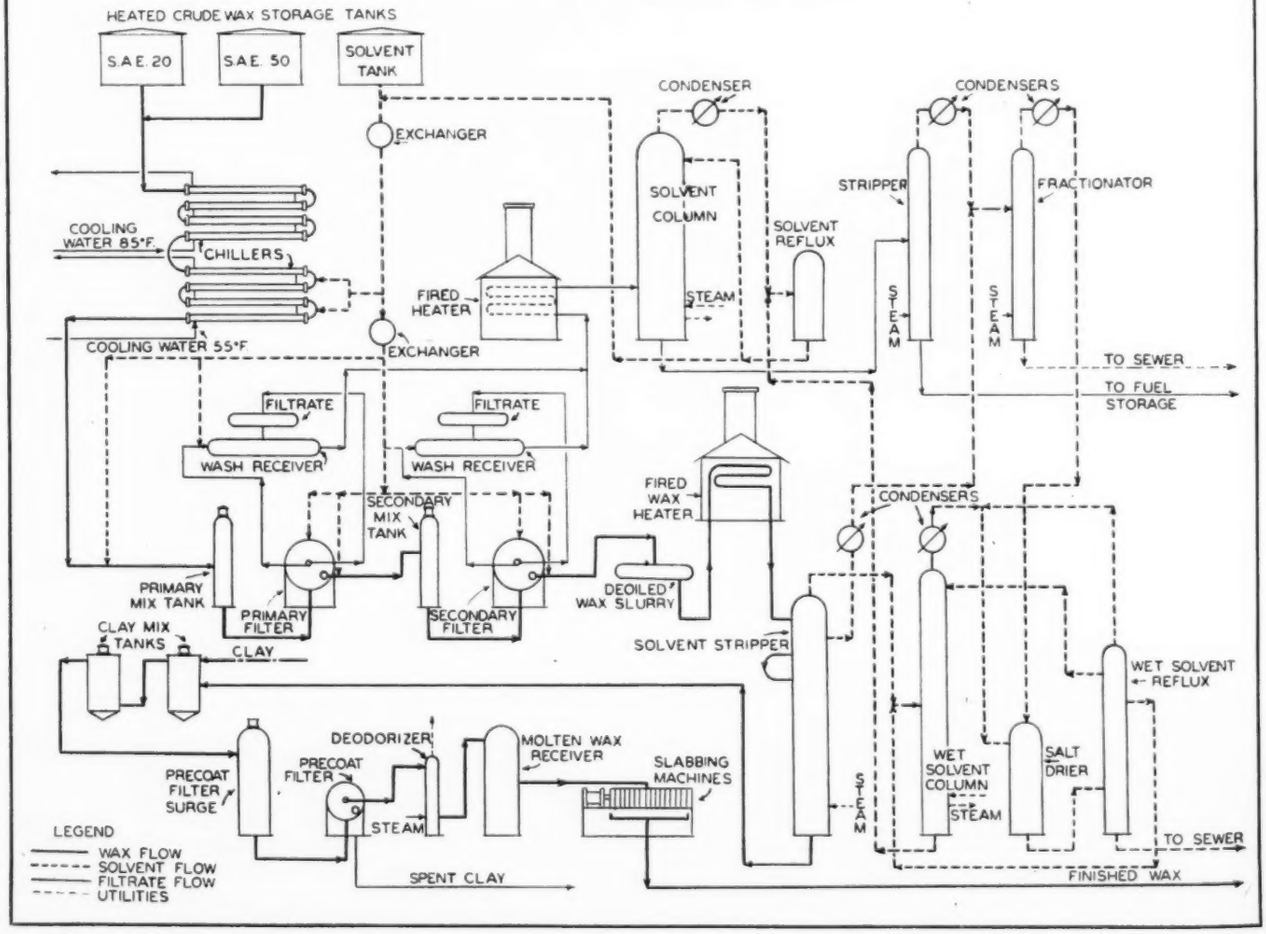
Laboratory tests of slurries made in this manner showed that essentially all high-melting-point wax (which constituted approximately 50 percent of the wax content of the crude waxes studied) was crystallized in an oil-free condition before the mixture reached room temperature. By the use of an appropriate solvent under proper conditions, these high-melting-point waxes were found to be recoverable in an oil-free condition by extracting or leaching the oil from the slurries. It was necessary, of course, to use the proper solvent in correct amounts for the different viscosity oils and to maintain proper conditions for the extraction or leaching operation. Chilling rates were found to be important and properly cooled slurries gave wax cakes of good crystalline structure essentially oil-free. Many waxy long residuum raffinates and crude waxes from such raffinates can be deoiled successfully by this process but, because petrolatum type wax contained in these materials usually lead to low filter rates and poor color in the finished product, it is considered preferable to distill a petrolatum-free fraction from such stocks for deoiling rather than deoil the entire mixture.

After obtaining necessary laboratory data a pilot plant was constructed to determine the engineering requirements for a commercial plant. The pilot plant consists mainly of a wax chiller; a vessel equipped with a high-speed electric-motor-driven stirrer for mixing the chilled waxy charge with solvent; calibrated vessels for solvent storage; a solvent recovery column; a continuous-vacuum filter, and the necessary pumps for transference of solvent and wax-oil slurry. Power for the pumps and for rotating the stirrer and filter is provided by one motor through line-shafts, clutches, gear reduction units, and belt drives.

The pilot plant operates on batches with approximately 50 lb. of the waxy material to be deoiled being weighed into the chiller at a temperature of from 150° to 160°F., the water in the chiller jacket being at the same temperature. The charge is then chilled at a uniform rate not exceeding 1°F. per minute. If the charge tends to stiffen too greatly before reaching the deoiling temperature, a necessary amount of solvent is added and the chilling continued. The deoiling temperature usually desired is from 65° to 75°F. and when this is reached the chilled waxy material is mixed with the required volume of solvent (methyl-ethyl-ketone or a mixture of this with naphtha), which is added at the same temperature as the chilled charge.

This primary slurry is filtered and washed on the filter with solvent at the same temperature as the slurry and the wax cake recovered is weighed. A small piece being removed for analysis of solvent content, the cake is placed in the cleaned mixing chamber where it is re-slurried by stirring with additional fresh solvent. The same procedure is followed with the secondary slurry and

Fig. 1. Flow diagram of wax-refining process



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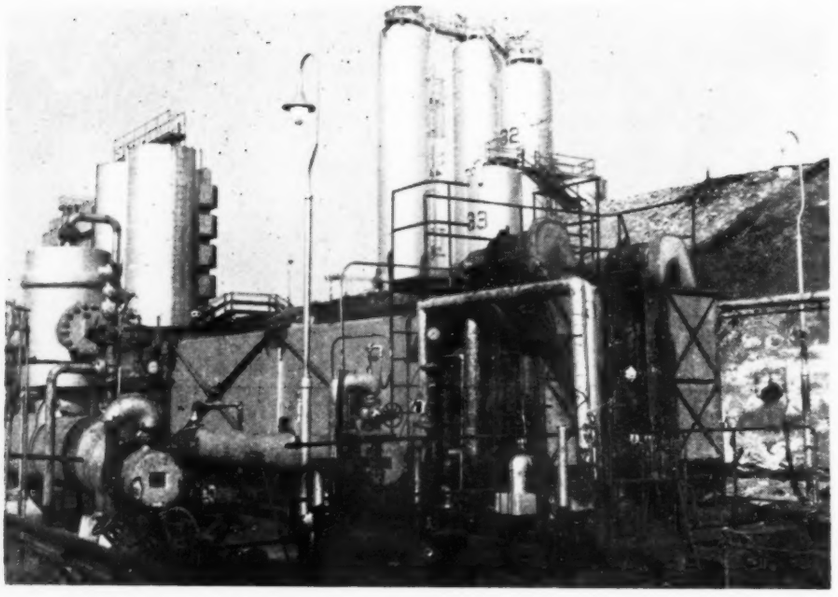


Deoiling plant wax chillers

the wax cake resulting is topped free of solvent under vacuum. The recovered wax is then clay-treated to color and the finished material is analyzed for oil content and subjected to physical tests.

The data provided by the pilot plant gave valuable information as a guide for the operation of the commercial plant as well as for its construction. At present the pilot plant is being operated on crude wax and waxy raffinate samples submitted by other refiners.

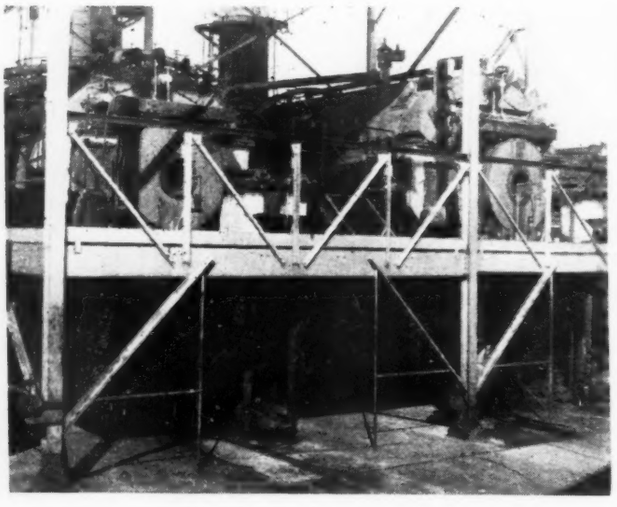
Oleum Wax Plant

The commercial plant designed and erected for utilization of the new deoiling process provides, of course, for continuous charging but follows as closely as possible the sequence of operations as developed in the batch-type pilot plant. The capacity of this plant is 500 bbl. per day of crude wax obtained by propane dewaxing of vacuum distillates, which finish to S.A.E. 20 and 40 grade oils. When operated at this feed rate, the wax content of the material being processed should produce about 20 tons per day of finished wax melting at either 145° to 150°F. or 160° to 165°F., depending on the grade of wax being processed. The complete process is indicated by Fig. 1, which gives a simplified flow sheet of the plant and shows the flows of wax, solvent, and filtrate but not the inert gas blanketing system being used to decrease the loss of solvent.

The two grades of crude wax to be deoiled are stored in separate 5000-bbl. tanks equipped with steam coils to maintain the temperature of the crude wax above the melting point. The methyl-ethyl-ketone solvent is stored in a similar tank. The liquid crude wax is pumped from the storage tank to two banks of continuous, double-pipe, scraper chillers connected in series, each bank consisting of 40-ft. sections of 6-in. pipe jacketed in 8-in. pipe and each supplied with a separate stream of cooling water flowing in opposite direction to the crude wax charge. The crude wax enters the first bank at 150° to 165°F. and the water, entering at 85°F., cools it to 115° to 120°F. At this temperature the crude wax passes to the second chiller bank into which the cooling water enters at 55°F. A manifold connection to each of the pipes in this bank provides for the introduction of solvent to reduce the consistency of the chilling wax charge and thus prevent an undue pressure rise that might cause twisting off of the scraper shaft heads. With the higher melting point crude wax, a small amount of solvent must be added when the temperature in the crude wax reaches 100° to 105°F. In processing the wax of lower melting point no introduction of solvent is usually necessary when it enters the second bank of chillers.

A volume of solvent equivalent to one-third to one-half that of the crude wax rate flow, or an addition of solvent that will bring the volume up to that proportion, is introduced into the last pass in the second chiller bank to reduce the consistency of the chilled wax and lessen the pressure drop in the line carrying it to the primary mix tank. The temperature of the crude wax leaving the chillers is controlled to produce waxes of the particular melting points required but this temperature is generally between 70° and 75°F.

General view of filters



Deoiling plant packaging equipment

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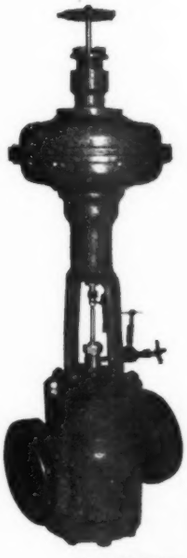

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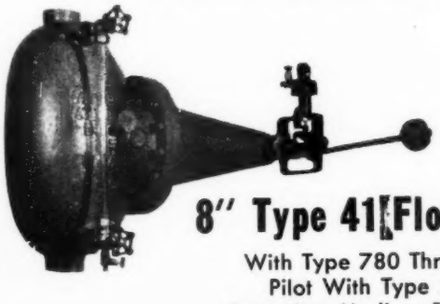

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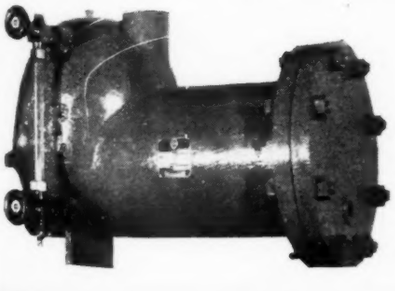

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The chilled wax and solvent is pumped to the primary mix tank, a vertical vessel 4 ft. in diameter by 10 ft. high and equipped with a motor-driven stirrer. Additional solvent at the same temperature as the chilled charge is here pumped in at a rate that will bring the total volume of solvent up to 1.5 to 2.0 times that of the crude wax. This primary slurry is then pumped to a continuous-vacuum, primary filter, with drum 10 ft. in diameter by 16 ft. long, which is totally enclosed in a pressure housing to prevent loss of solvent by evaporation. The primary slurry is here filtered under a vacuum of from 3 to 5 in. and the wax cake formed is washed under a vacuum of 20 to 25 in., using a volume of fresh solvent equivalent to 0.5 to 1.0 times that of the crude wax in the slurry.

In order to maintain different degrees of vacuum on the filtering and washing sections of the filter, the filtrate and wash liquids are collected separately. In the 2-ft. diameter by 7-ft. horizontal filtrate receiver the filtrate is kept at a constant level, the excess being pumped to the wash solvent receiver where it is mixed with the wash solvent. The wash solvent receiver is a 2-ft. diameter by 12-ft. horizontal vessel from which the combined filtrate and wash solvent are pumped to the filtrate solvent recovery system.

The discharged wax cake, removed by gas blow and scraper bar, falls on to a scroll where it is slurried with an additional amount of fresh solvent equivalent to 0.5 to 1.0 times that of the crude wax being processed. This thick mixture is pumped to the secondary mix tank, a duplicate of the primary tank, where it is diluted with additional solvent sufficient to bring the amount to 1.0 to 1.5 times that of the crude wax. This secondary slurry is pumped to the secondary filter in which the drum is 8 ft. in diameter and 12 ft. in length and is here filtered under a vacuum of 3 to 5 in. The cake formed is washed on the filter with additional solvent equivalent to 0.5 to 1.0 times the volume of the crude wax.

The filtrate and solvent are collected separately as in the primary filtering operation and then combined before being pumped either to the solvent recovery system or to the second chiller bank and primary mix tank to provide solvent for the primary slurry. The recirculation of filtrate and wash solvent from secondary filter (not shown on the flow sheet) lightens the load on the solvent recovery system and has no adverse effect on the process because the total amount of oil and wax in solution in the combined streams is not more than 1 to 2 percent by volume of the solvent present.

TABLE I

Aristowax samples	145°-150°	160°-165°
Crude wax tests		
Oil content, percent by weight	61.0	71.0
Melting point, °F.	125.0	124.0
Deoiled wax tests		
Yield, percent by weight	26.2	16.4
Melting point, °F. (AMP)	146 (a)	162 (b)
Specific gravity	0.895	0.192
Viscosity, S.S.U. at 210° F.	42	50
Penetration at 77° F.	16	15
Oil content, percent by weight	0.47	0.41
Tensile strength, lb. per sq. in.	143	191

(a) Equivalent to 143° F. A.S.T.M. melting point.
(b) Equivalent to 150° F. A.S.T.M. melting point.

The wax cake from the secondary filter is handled in the same way as that from the primary filter and is also mixed with an amount of solvent equivalent to 0.5 to 1.0 times the volume of the crude wax. The resulting slurry is pumped to the deoiled wax slurry tank from which it is fed to the wax stripper system. This system is connected to the filtrate solvent recovery system by cross-circulation of the wet solvent vapor streams, the water being introduced as steam in the stripping of the hot filtrate and wax bottoms.

The filtrate recovery system consists of a fired heater; a fractionating column, 7 ft. in diameter by 50 ft. high; a solvent reflux storage drum, 8 ft. in diameter by 10 ft. long; and two packed columns 2 ft. in diameter by 40 ft. high. One of the packed columns is used to steam-strip the filtrate bottoms from the main column and the other to obtain a concentration of the solvent from the dilute water solutions obtained in the steam-stripping operations.

The wax stripper system consists of a fired heater; a main stripper column, 4 ft. in diameter by 33 ft. high and equipped with a flash drum; a wet solvent column; a salt drier column, 4 ft. in diameter by 10 ft.; and a combined wet solvent reflux drum and solvent-water separator 3 ft. in diameter by 12 ft. in length.

The combined filtrates and washed solvents from the filters pass through the heater to the filtrate fractionating column at a point below its middle. (An optional method by which the combined filtrate and wash solvent from the secondary filter are recirculated to form the primary slurry is not shown on the flow sheet in Fig. 1.) The solvent, taken overhead, is condensed and collected in the solvent reflux storage drum from which a portion is circulated back to the column for reflux. The hot filtrate bottoms enters the packed stripper column at approximately its middle and is stripped completely of solvent by steam introduced at the bottom of the column. The stripped bottoms consists of low-melting-point waxes and oil and this mixture is pumped to fuel oil storage.

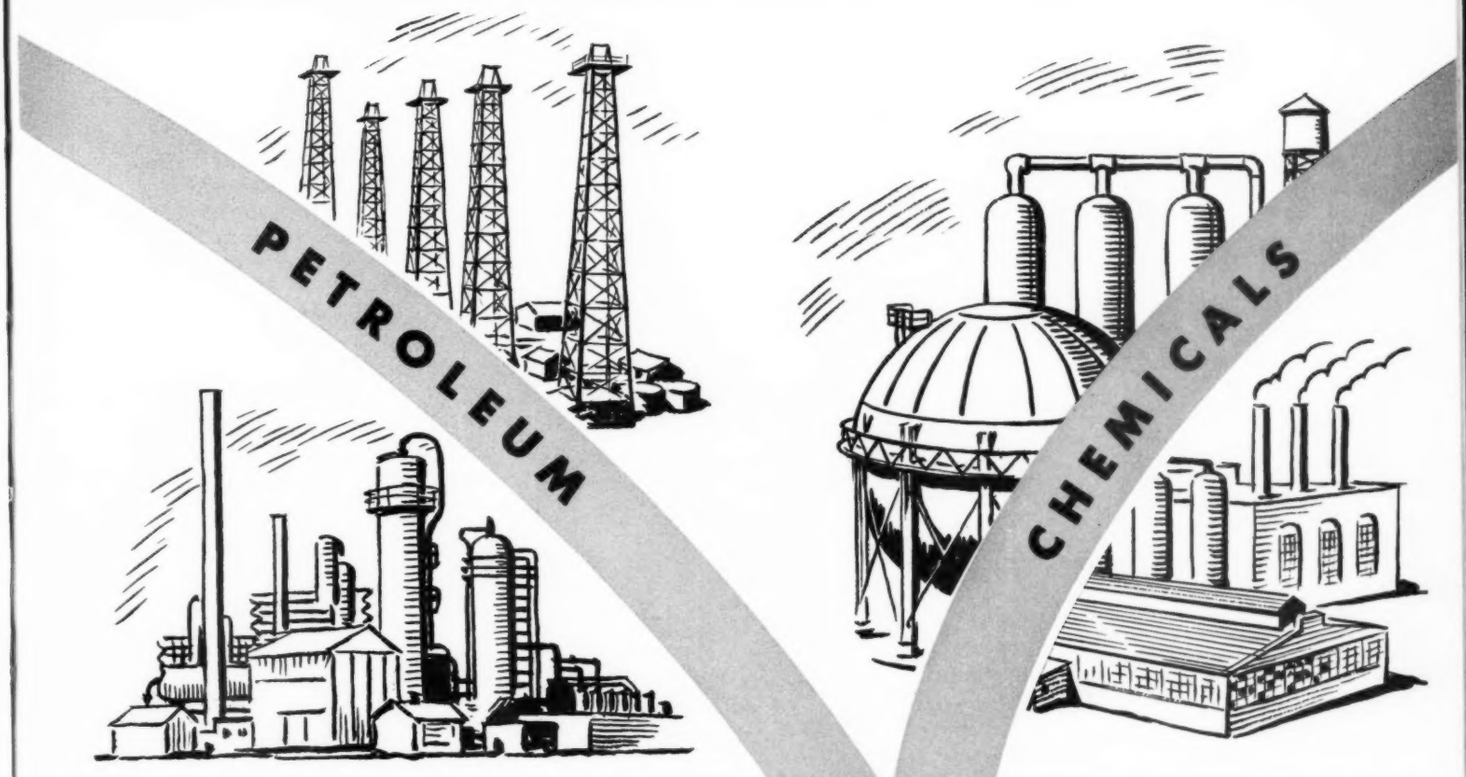
The solvent vapor and steam is condensed and fed to the other packed column at a point above its center for solvent-water fractionation. It is here combined with a similar overhead stream from the wax stripper system. Steam, entering the bottom of this column, strips the solvent from the water and leaves a bottoms consisting of water with less than 1 percent of solvent, which is drawn to waste. The overhead consists of approximately 40 percent of methyl-ethyl-ketone and 60 percent water, which is condensed and pumped to the salt drier.

The deoiled wax and solvent slurry is pumped from its tank through the fired heater to the wax stripper column. This stream enters the flash drum in the top of the column and the solvent flashed overhead passes as vapor to the center of the wet solvent column. The bottoms from the flash drum flows downward through the stripper where steam introduced at the bottom of the column strips off the solvent. After being condensed, the overhead mixture of solvent and steam passes to the center of the solvent-water fractionator in the filtrate recovery system as stated above.

The overhead from the flash drum is mixed with wet solvent from the solvent-water separator as it enters the wet-solvent column, which is equipped with a steam reboiler. The bottoms is dry solvent, which is returned to the solvent reflux drum for reuse. The overhead from this column is the azeotrope of solvent and water, which stream, after condensation, is divided, one portion passing to the salt drier column and the remainder to the wet solvent reflux drum for recirculation.

The portion of wet solvent going to the salt drier column from the overhead of this column is combined with the overhead from the filtrate solvent recovery system and this stream passes through the salt drier column where the water in the solvent dissolves sufficient salt to cause a separation into two phases, the mixture flowing to the solvent-water separator where it is settled. The lower liquid phase consisting of a salt water solution containing a small amount of solvent is withdrawn from the separator and discarded; the upper liquid phase consisting of wet solvent is returned to the wet solvent column as stated above.

The deoiled wax (the bottoms of the wax stripper) is pumped at a temperature of approximately 450°F. to the first clay mix tank, which is fed continuously with Filtrol clay at a rate proportional to the rate of flow of the



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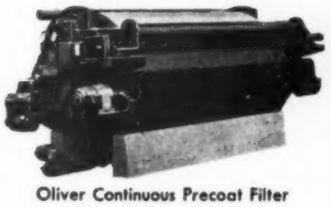

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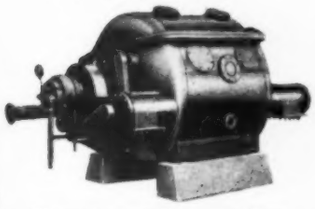

Oliver Continuous Pressure Filter

Oliver Panel Type Filter

wax stream entering the tank. A high-speed stirrer in this tank insures good contact between the liquid wax and clay and prevents settling of the clay. The wax-clay mixture overflows from this tank to a second clay mix tank of similar design to provide sufficient contact time. The mixture then overflows to a precoat filter surge tank where it is kept stirred to prevent settling of the clay. It is then pumped to a continuous precoat vacuum filter 3 ft. in diameter by 4 ft. in length. The clay is removed from the decolored wax by means of this filter. From the wax receiver the clay-treated product is pumped to a small steam stripper where it is deodorized. From here it is pumped to the refined wax storage tank.

In using this process the maximum volume of solvent necessary is 6.5 times the volume of crude wax being deoiled. Of this amount the required portion of 2.5 volumes employed in the secondary filter operations may be recycled to form the primary slurry, thus leaving only 4.5 volumes to be recovered by the solvent recovery system.

The refined wax produced by the plant now in operation is marketed under the trade name of Aristowax and the typical characteristics of the two melting-point grades are shown in Table 1. The lower melting point product "Aristowax 145°-150°" is obtained in a yield of approximately 25 to 27 percent from the crude wax produced from the S.A.E. 20 distillate; the higher-melting-point product "Aristowax 160°-165°" is obtained in a yield of 15 to 17 percent from the crude wax from the S.A.E. 40 vacuum distillate. The refined wax is either filled into wooden barrels or slabbed and packed into cartons. Two slabbing machines of conventional design, each with a capacity of 120 slabs, produce slabs approximately 19 in. by 12 in. by 1½ in. and weighing 10 lb. each, which are packed into cartons holding 10 slabs apiece.

Adaptation of Process

Although there is a present shortage of high-melting-point waxes the wartime restriction on construction materials make it improbable that new wax-deoiling plants will be constructed for some time. Two modifications of the process, however, offer distinct possibilities of incorporation into existing refining operations without the necessity for extensive construction.

One of these modifications is adaptable to refineries now producing ordinary paraffin waxes melting up to approximately 138°F. by the conventional cold pressing and sweating procedure described by Ralph H. Espach.[2] By combining the existing operation with this new process, waxy distillates, usually of less than 100 S.S.U. viscosity at 100°F., are chilled to approximately 20°F. in order to crystallize the wax and are then filtered under high pressure to produce crude wax cakes containing up to 60 percent oil. These cakes are melted and run to sweater pans where the wax is freed from oil and fractionated into different melting point products by repeated resweatings. By using the combined process the sweating operation is shortened, there is less loss of wax and the decreased volume of drier wax cake produced requires a smaller number of sweater pans.

The second modification is adaptable to existing dewaxing plants processing waxy raffinates by methods employing mixed solvents such as methyl-ethyl-ketone and benzene. By combining this process with the new process here described, the high-melting-point waxes in the raffinates may be recovered in an oil-free condition without increasing the solvent recovery load on the existing wax plant equipment. At the same time the yield of dewaxed oil is improved and the refrigerating load is decreased. The total volume of solvent employed by the combined processes is no greater than that required for the dewaxing alone with the existing plant.

[2] "Manufacture of Paraffin Wax from Petroleum," U. S. Bureau of Mines Bulletin No. 388.

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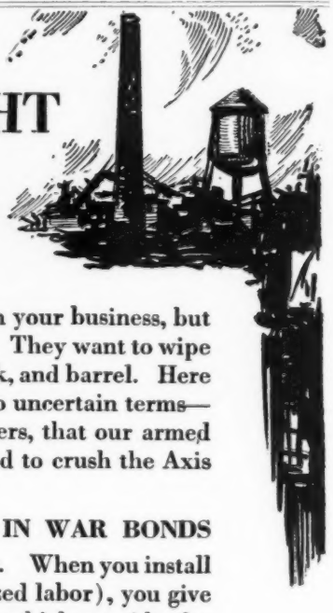

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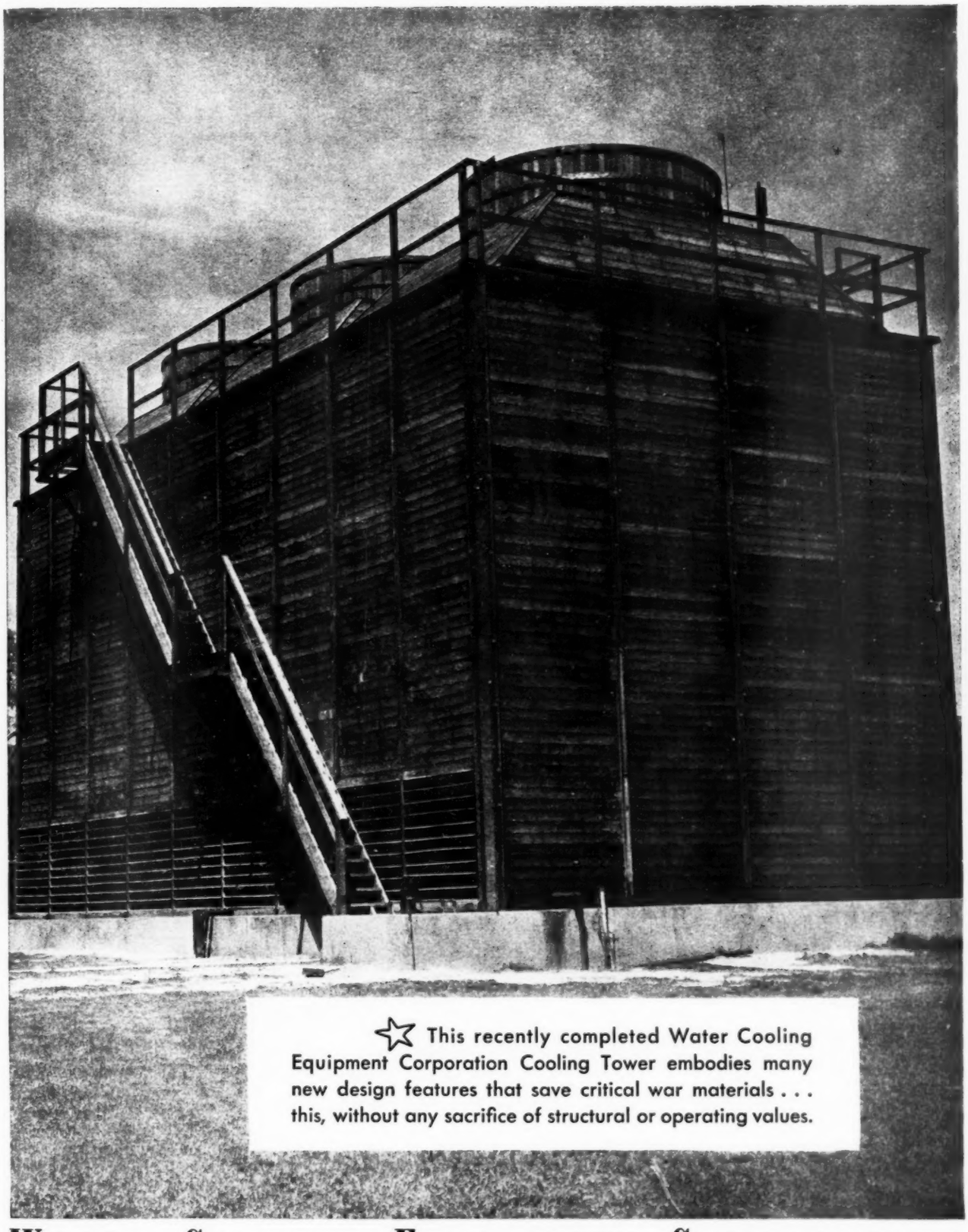

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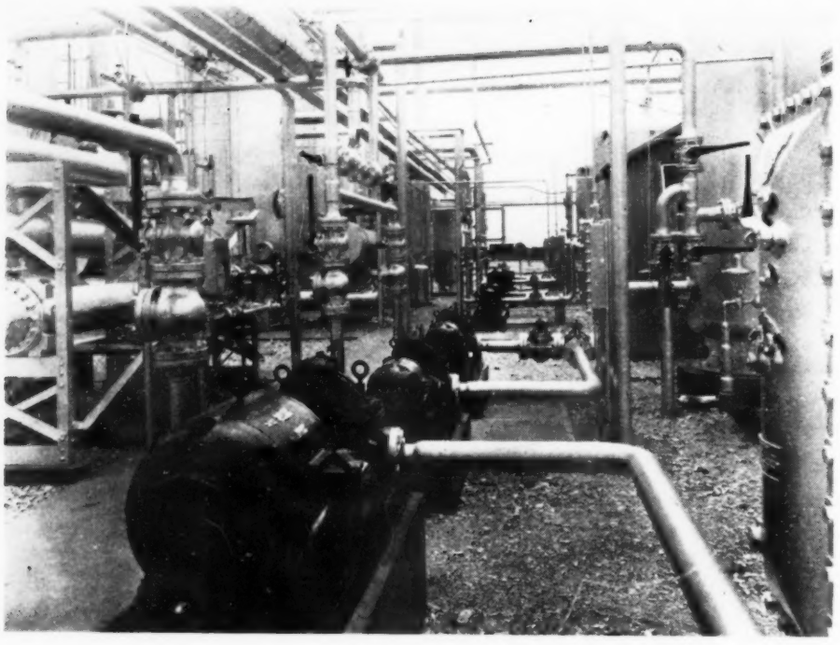

Adequate maintenance for motors and generators is essential to avoid breakdown and keep equipment running efficiently

PETROLEUM ENGINEER Exclusive Feature

PART 1

Maintaining Electric Motors and Generators

☆ Preventive maintenance is a "must" for the duration

by E. H. Lamberger, Petroleum Engineer, and
W. W. McCullough, Maintenance and Repair Engineer
Westinghouse Electric and Manufacturing Company

E. H. LAMBERGER

is an application engineer in the petroleum and chemical section of the industry engineering department of Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania—Since 1936 his activities have been mainly directed toward the production of petroleum, assisting in such developments as variable voltage d-c. drilling equipment, a-c. drilling equipment, and all types of oil-well pumping—He has been with Westinghouse since 1921, the year he graduated from Ohio State University in electrical engineering.

THE petroleum industry is one of the most vital in our present emergency. It has a task to accomplish that requires unfailing operation of every piece of equipment in every branch of the industry—production, transportation, refining, and marketing. Downtime of a machine is not simply a question of one operation suspended, instead it must be considered as the failure in a chain with the resulting loss of production causing an unrecoverable void in a production that at best is insufficient.

Electric motors and generators are used in all branches of the petroleum industry. They supply motive power to drilling rigs, well-pumping equipment, pipe-line pumping stations, refineries, storage and bulk stations, marine terminals, and retail marketing stations. The electric motors used are of almost every conceivable rating and type; large and small, low and high speed, alternating current and direct current, open type for indoor installations or enclosed type for outdoor service or for hazardous locations, sleeve bearing or "anti-friction" bearing and a wide va-

W. W. McCULLOUGH

is service engineer in the Maintenance Department of the East Pittsburgh Works of Westinghouse Electric and Manufacturing Company. He graduated from the University of Texas in 1909, receiving the degree of bachelor of science and electrical engineering—Joined Westinghouse in 1914 and worked as electrical engineer on test floor—Has been directly connected with problems involving the installation of electrical apparatus in industrial plants and power stations and with maintenance work most of this time.

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TABLE I
General good maintenance practices

Keep motor off line when not needed.	Saves unnecessary wear of brushes, commutator and bearings, saves lubrication.
Do not leave field circuit excited unless motor has been especially designed for this type duty.	Check temperature of shunt fields with thermometer to see that temperature does not exceed 90°C. When field must be excited, caution maintenance men to be sure field circuit is opened before working on the motor.
Keep motor clear of metal dust or cuttings that can be drawn into windings and pole pieces.	Magnetic attraction will draw metal parts into the air gap and damage windings.
Reassembling of motor.	Be sure to retain proper air gaps in motor by checking bore of pole faces before dismantling. Reassemble, replacing poles and liners in original position.
Note wearing parts and parts frequently replaced to determine anticipated repairs.	Carry a proper store room stock of replacement parts. Make survey of standard repair parts to avoid duplication of parts to be carried.

riety of more specialized types. Regardless of its size, type, or location, the motor is doing a job; it requires systematic inspection and repair to assure continuity of operation, and must be included in a comprehensive inspection and maintenance program.

A schedule calling for routine, periodic inspection, and preventive maintenance of each machine must be backed by an adequate stock of renewal parts and maintenance supplies and facilities. A modern soldier could not travel far on worn-out shoes, and neither can a machine do its job on worn-out parts. An effective schedule with adequate renewal parts makes maintenance, and consequently operation, easier because it eliminates confusion, oversight, and shutdowns. It results in lower cost operation.

The layout of the maintenance program, the periods between inspection, replacements, and overhauls must be determined locally as they will vary widely with type of operation and plant and for each motor or group of motors. Thus the program for a drilling rig is different from that for a refinery. Every program must include every motor, and take into consideration its operating conditions. No motor must be left to groan in trouble unseen and unheard. Records must be kept consistently on the schedule set up. Several excellent record systems have been developed and are available in printed form.

Basic Inspection Periods

Although it is impossible to give any hard and fast rules for frequency of inspection, the following suggestions may be considered adequate for conditions of ordinary severity:

Once a week check oil level in the bearings and see that the oil rings are moving freely. Check the temperature of the motor bearings and primary iron with the hand. Sniff the warm air coming from open motors. The fumes emanating from overheated insulation are unmistakable.

Once a month check the brush holders, brushes, and shunts. Blow out the motor with compressed air.

Once a year check air gap with feeler gauge. Check insulation resistance with Megger. Check line voltage with voltmeter, and load with ammeter. Clean out and replace grease in ball and roller bearings. Check renewal parts stock in light of the last year's experience.

Every two years dismantle the motor. See that all windings are tight. Replace loose wedges and loose bands before dipping in varnish and baking. Inspect commutators and commutator connections and slip rings. Sleeve bearings require no flushing. At intervals of about two years in average service, or during general overhaul periods, remove the

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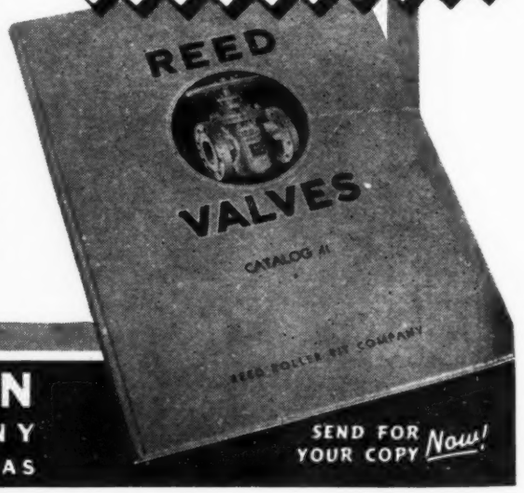

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bracket and wash out the bearing housing. Use hot kerosine oil and compressed air if available.

Bearings

All motors depend upon a mechanical assembly of some sort for the transformation of electrical energy into mechanical energy or work. The bearings are a very important link in this mechanical assembly.

Bearings probably cause more shutdowns, delay, and expense than any other part. This is not surprising when it is remembered that they are victims of poor foundations, misalignment, vibration, thrust from couplings, dirt, under- and over-lubrication, and frequently contaminated or improper lubricant. All this in addition to their real job of supporting a rapidly revolving part.

Suggestions are made in the charts for minimizing or eliminating some of these causes of failure, but a brief study of motor bearings may be helpful.

Sleeve Bearing Lubrication

In a sleeve bearing the oil sticks to the shaft and is dragged along by the rotation of the shaft so as to form a wedge-shaped film between the shaft and the bearing. This film of oil carries the load, and prevents metal-to-metal contact. So long as this film is established and maintained there is no metal-to-metal contact in the bearing while the shaft is rotating, and, therefore, no perceptible bearing wear. The oil is carried from the reservoir to the shaft by oil rings that ride on the shaft and dip into the reservoir. Two outstanding considerations, therefore, govern the maintenance of sleeve bearings. First, insure the existence of the oil film once rotation has begun. Use the right oil and keep rings rotating. Second, minimize the destructive effects of metal-to-metal contact when the film is lost, either by accident, or during the starting period. Use the right babbit.

Assuming the bearing is adequate for the job, lubrication of proper quality and quantity must be provided. Oiling of bearings is more often overdone than underdone. Keep oil wells filled only to the proper level. New oil should be added only when the motor is at rest to prevent overfilling of the reservoir. Sleeve bearings, which require frequent refilling, may be leaking oil onto the motor windings. Such bearings should be replaced with sealed sleeve-type bearings and brackets.

Oil rings generally carry far more oil than is necessary for proper lubrication of the bearing. Most of this oil is carried on the outside diameter of the rings. The excess oil causes splashing and spray inside the bearing housing. Air currents set up by rotating parts tend to pick up this spray and deposit it on motor windings. Sealing the bearing against the entry of air currents is, therefore, necessary and is accomplished in all modern designs by close tolerance, felt seals, and air bypasses.

The purpose of the felt washer in these seals is often misunderstood. The real purpose of the felt is to keep out air and dirt. In itself, it has little value for preventing leakage of oil once it becomes oil soaked. Bearing wear, which means radial movement of the shaft, spoils the effectiveness of the bearing seals. Replace all felt seals at the same time when replacing sleeve bearings. These felt seals should be ordered from the manufacturer of the motor. If it is necessary to make them in an emergency, use high-grade felt not less than ¼ in. thick before compression. Make the inside diameter of the washer the same as the shaft or slightly less. Cut the felt true with edges at right angles to the surface of the felt.

Oil leakage is generally aggravated by high temperatures. Keep bearings

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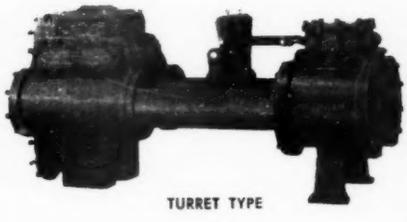
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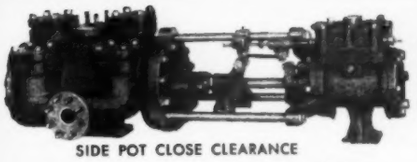
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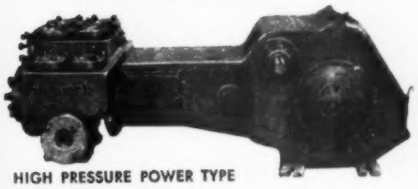
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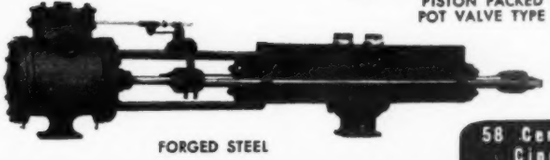
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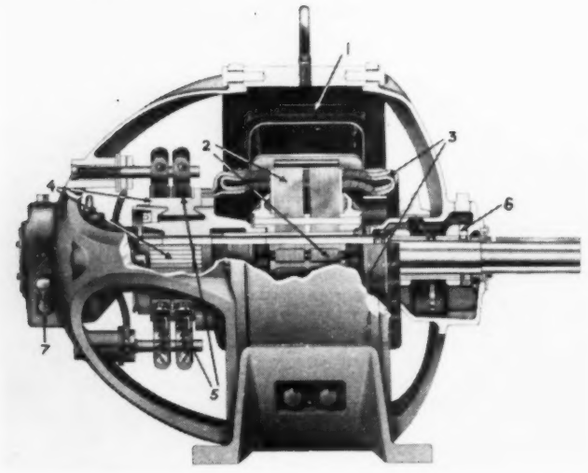
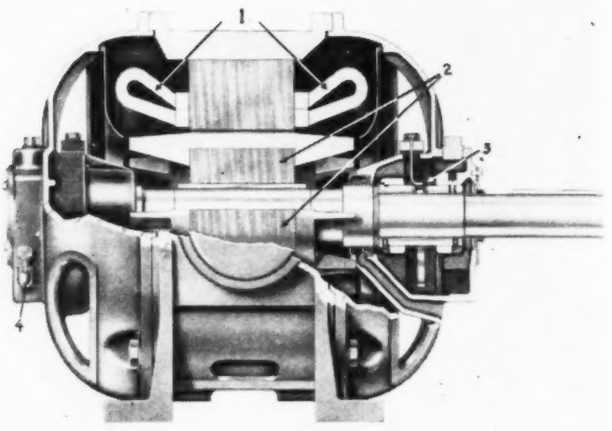


Cutaway view of d-c. motor; 1. field coils; 2. armature; 3. armature coils; 4. commutator; 5. brush rigging; 6. sleeve bearing; 7. oil overflow and filler plug



Cutaway view of a-c. squirrel-cage motor; 1. stator coils; 2. squirrel-cage rotor; 3. sleeve bearings; 4. oil overflow and filler plug

cool and use an oil that does not foam easily.

Heat Dissipation

The lubricant, in addition to preventing metal-to-metal contact, also cools the sleeve bearing by carrying the heat from the bearing surface to the oil reservoir.

A bearing housing may feel hot to the touch but still be operating within safe temperature limits. The bearings of the larger or lower speed motors may normally operate with a permissible temperature rise of 35 to 40°C. and with a surrounding temperature of 30 to 40°C. (86 to 104°F.) would feel hot to the hand. The smaller and higher speed motors usually operate with lower temperatures and may feel only comfortably warm. It is apparent that it is important to note a change in bearing temperature from one inspection to the next, rather than the actual temperature and to investigate any change to a higher value.

TABLE 2
A-C., D-C. motor maintenance check chart

CAUSE	WHAT TO DO
TROUBLE: *Hot bearings*	
Bent or sprung shaft.	Straighten or replace shaft.
Excessive belt pull.	Decrease belt tension.
Pulley too far away.	Move pulley closer to bearing.
Pulley diameter too small.	Use larger pulleys.
Misalignment.	Correct by realignment of drive.
TROUBLE: *Sleeve*	
Oil grooving in bearing obstructed by dirt.	Remove bracket or pedestal with bearing and clean oil grooves and bearing housing; add new oil.
Bent or damaged oil rings.	Repair or replace oil rings.
Oil too heavy.	Use a recommended lighter oil.
Oil too light.	Use a recommended heavier oil.
Insufficient oil.	Fill reservoir to proper level in overflow plug with motor at rest.
Too much end thrust.	Reduce thrust induced by driven machine or supply external means to carry thrust.
Badly worn bearing.	Replace bearing.
TROUBLE: *Ball*	
Insufficient grease.	Maintain proper quantity of grease in bearing.
Deterioration of grease or Lubricant contaminated.	Remove old grease, wash bearings thoroughly in kerosene and replace with new grease.
Excess lubricant.	Reduce quantity of grease. Bearing should not be more than ½ filled.
Heat from hot motor or external source.	Protect bearing by reducing motor temperature.
Overloaded bearing.	Check alignment, side thrust and end thrust.
Broken ball or rough races.	Replace bearing; first clean housing thoroughly.
TROUBLE: *Oil leakage from overflow plugs*	
Stem of overflow plug not tight.	Remove, re-cement threads, replace and tighten.
Cracked or broken overflow plug.	Replace the plug.
Plug cover not tight.	Requires cork gasket, or if screw type, may be tightened.
TROUBLE: *Motor dirty*	
Ventilation blocked, end windings filled with fine dust or lint.	Clean motor will run 10 to 30°C. cooler. Dust may be cement, sawdust, rock dust, grain dust, coal dust and the like. Dismantle entire motor and clean all windings and parts.
Rotor winding clogged.	Clean, grind and undercut commutator. Clean and treat windings with good insulating varnish.
Bearing and brackets coated inside.	Dust and wash with cleaning solvent.
TROUBLE: *Motor wet*	
Subject to dripping.	Wipe motor and dry by circulating heated air through motor. Install drip or canopy type covers over motor for protection.
Drenched condition.	Motor should be covered to retain heat and the rotor position shifted frequently.
Submerged in flood waters.	Dismantle and clean parts. Bake windings in oven at 105°C. for 24 hours or until resistance to ground is sufficient. First make sure commutator bushing is drained of water.

Ball or Roller Bearings

In ball or roller bearings a series of steel balls or rollers act as the separating medium between shaft and stationary parts. A cage or retainer is used to keep the balls or rollers uniformly spaced around the shaft. The balls or rollers have sliding contact with the retainer, and consequently lubrication is required.

Most ball or roller bearings as used in horizontal motors are grease lubricated, although some supplied with vertical motors use oil. The advice of the motor manufacturers should be followed in selecting a suitable lubricant. Carelessness in allowing containers to remain open causes trouble from abrasive dirt. Soda-base soap greases are usually preferred because of their high melting point and their stability. They mix readily with water, however, and tend to form an emulsion.

Ball or roller bearings in distress can usually be detected by undue heating or by unusual noise. Broken or nicked balls cause rapid destruction of the bearing, and are frequently detected by a "clicking sound."

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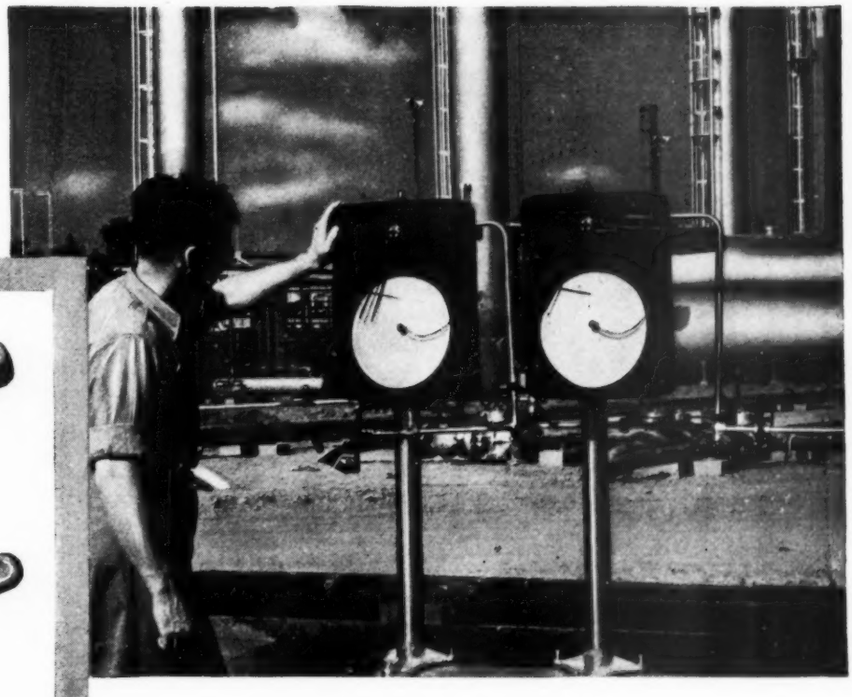

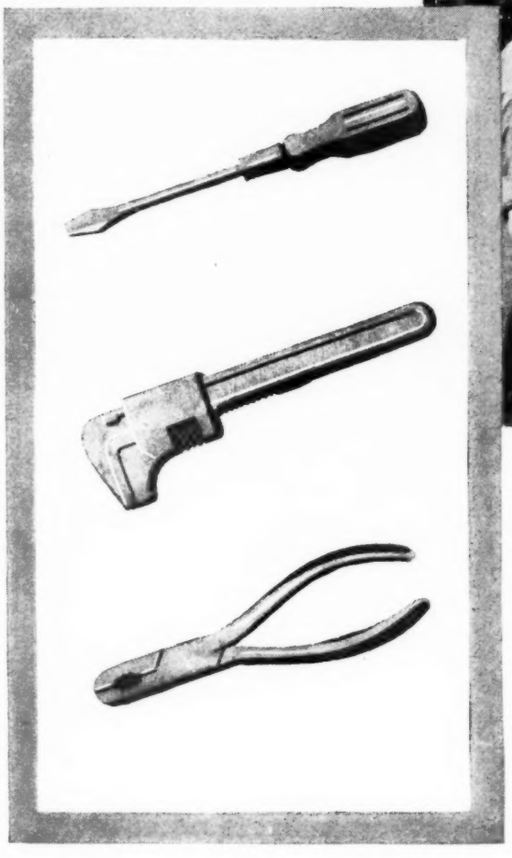

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TABLE 3

Trouble correction chart for a-c. motors

CAUSE	WHAT TO DO
TROUBLE: *Motor stalls*	
Wrong application.	Change type or size. Consult manufacturer.
Overloaded motor.	Reduce load.
Low motor voltage.	See that nameplate voltage is maintained.
Open circuit.	Fuses blown, check overload relay, starter and pushbutton.
Incorrect control resistance of wound rotor.	Check control sequence. Replace broken resistors. Repair open circuits.
TROUBLE: *Motor connected but does not start*	
One phase open.	See that no phase is open.
Motor may be overloaded.	Reduce load.
Rotor defective.	Look for broken bars or rings.
Poor stator coil connection.	Remove end bells, locate with test lamp.
TROUBLE: *Motor runs and then dies down*	
Power failure.	Check for loose connections to line, to fuses and to control.
TROUBLE: *Motor does not come up to speed*	
Not applied properly.	Consult supplier for proper type.
Voltage too low at motor terminals because of line drop.	Use higher voltage on transformer terminals or reduce load.
If wound rotor, improper control operation of secondary resistance.	Correct secondary control.
Starting load too high.	Check load motor is supposed to carry at start.
Low pull-in torque of synchronous motor.	Change rotor starting resistance or change rotor design.
Check that all brushes are riding on rings.	Check secondary connections. Leave no leads poorly connected.
Broken rotor bars.	Look for cracks near the rings. A new rotor may be required as repairs are usually temporary.
Open primary circuit.	Locate fault with testing device and repair.
TROUBLE: *Motor takes too long to accelerate*	
Excess loading.	Reduce load.
Poor circuit.	Check for high resistance.
Defective squirrel-cage rotor.	Replace with new rotor.
Applied voltage too low.	Get power company to increase voltage tap.
TROUBLE: *Wrong rotation at start*	
Wrong sequence of phases.	Reverse connections of motor or at switchboard
TROUBLE: *Motor overheats while running under load*	
Check for overload.	Reduce load.
Wrong blowers or air shields, may be clogged with dirt and prevent proper ventilation of motor.	Good ventilation is manifest when a continuous stream of air leaves the motor. If not, check manufacturer.
Motor may have one phase open.	Check to make sure that all leads are well connected.
Grounded coil.	Locate and repair.
Unbalanced terminal voltage.	Check for faulty leads, connections and transformers.
Shorted stator coil.	Repair and then check wattmeter reading.
Faulty connection.	Indicated by high resistance.
High voltage.	Check terminals of motor with voltmeter.
Low voltage.	
Rotor rubs stator bore.	If not poor machining, replace worn bearings.
TROUBLE: *Motor vibrates after corrections have been made*	
Motor misaligned.	Realign.
Weak foundations.	Strengthen base.
Coupling out of balance.	Balance coupling.
Driven equipment unbalanced.	Rebalance driven equipment.
Defective ball bearing.	Replace bearing.
Bearings not in line.	Line up properly.
Balancing weights shifted.	Rebalance rotor.
Wound rotor coils replaced.	Rebalance rotor.
Polyphase motor running single phase.	Check for open circuit.
Excessive end play.	Adjust bearing or add washer.
TROUBLE: *Unbalanced line current on polyphase motors during normal operation*	
Unequal terminal volts.	Check leads and connections.
Single phase operation.	Check for open contacts.
Poor rotor contacts in control wound rotor resistance.	Check control devices.
Brushes not in proper position in wound rotor.	See that brushes are properly seated and shunts in good condition.
TROUBLE: *Scraping noise*	
Fan rubbing air shield.	Remove interference.
Fan striking insulation.	Clear fan.
Loose on bedplate.	Tighten holding bolts.
TROUBLE: *Magnetic noise*	
Air gap not uniform.	Check and correct bracket fits or bearing.
Loose bearings.	Correct or renew.
Rotor unbalance.	Rebalance.

Over-Greasing Raises Heat

The temperature limits for ball or roller bearings are about the same as for sleeve bearings. The first result of over-greasing is over-heating, caused by churning of the grease. Look for an overfilled bearing. The general rule is that the housing should not be more than half full. Clean the old grease from the bearing and from the housing once a year and replace it with new grease. Average service is assumed.

After the machine is dismantled, the bearing should be carefully wrapped in clean cloth or paper to protect it from outside dirt. Remove all old grease from the housing and clean the housing and the bearing either in Stoddard solvent or in carbon tetrachloride. This is a difficult operation because particles of grit are not soluble and are removed with difficulty. Remove the final residue of cleaning medium with a light oil before filling with new grease. The container with fresh grease must be carefully protected from dirt. Keep the cover on tight. Use a clean nonmetallic paddle for applying the fresh grease.

Check Air Gap

The air gap in a motor is dependent first on proper maintenance of the bearings and second on the proper alignment of the brackets or pedestals with the frame. Alternating-current motors operate with less gap than d-c. motors, and are therefore more critical. Check the air gap with a feeler gauge at the established schedule period. Make these checks at the pulley end, taking four readings on each motor 90° apart. For motors below 10 hp., a minimum gap of 0.005 in. should be maintained. Above 10 hp. the minimum gap should be 0.010 in.

Alignment of Couplings

Couplings require regular inspection. Faulty alignment in a solid coupling is reflected in bearing trouble and vibration. Make sure that all dowel pins are in correct position and check the faces of the couplings with a feeler gauge after the bolts have been removed. Shift the motor position to make the faces of the two half couplings parallel.

Flexible couplings will operate under more severe misalignment without causing trouble; however, the two halves should be checked with a steel straightedge to make sure they are in alignment. Any misalignment means increased wear on the pins, fingers, or leather disks, whichever may be used. Special type flexible couplings should be checked according to the manufacturer's instructions.

Editor's Note: This article will be continued in an early issue.

☆ ☆ ☆

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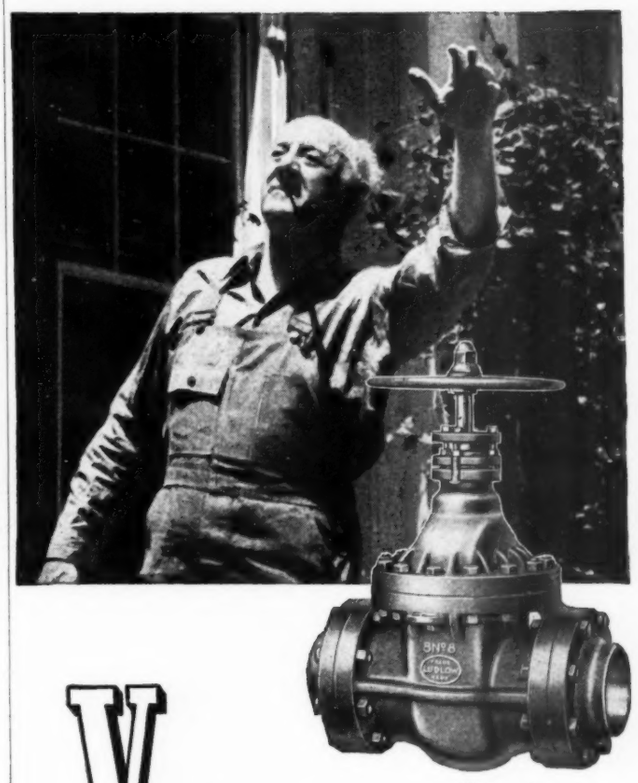

Veterans hold the Home Front

Back into overalls they go—men that had retired to easy chairs—valves that had been called useless and retired to a store-house corner. They've got to hold the "home front" now. Oil Men are seeing to it that recent installations are maintained with care and that old-timers are restored with replacement parts, spruced-up and put back in the ranks.

Fortunately, Ludlow quality means that even cast-off old-timers may still give service with a reasonable replacement of working parts. Under priority, Ludlow can furnish these parts for you—should priority on new valves be impossible or difficult to get. Our full co-operation is always assured.

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Construction Features: Self-releasing 30° angle wedges and free-floating gates, self-adjusting to seats, afford smooth, trouble-free performance, long service. Rings are cleaned throughout stroke action. Gates are wedge-locked directly opposite ports and completely unwedged before rai ing. Ample tolerances provide easy action. Simple construction permits easy replacement of parts.

LUDLOW VALVES

SINCE 1866

Procedure For Proper Boiler Operation

PETROLEUM ENGINEER Exclusive Feature

☆ Timely suggestions for effecting greater efficiency and longer life of equipment

by J. L. Massie, Manager, Southwestern
Field Service Division, Henry Vogt Company

THE PURPOSE of this article is to outline the procedure for proper boiler operation. Only large steam generating boiler installations are considered. Because of a scarcity of skilled boiler house manpower, the simple principles set forth in this article may be of added value at this time.

Scarcities of critical materials have favored construction of larger and fewer units, rather than the smaller installations. As many of these installations have been made in existing boiler plants, the importance of correct procedure in bringing boilers on and off the line is even greater than when all installations have already been set up and are operating under similar pressure conditions.

On the financial side of the picture, the boiler house engineer who formerly operated a boiler unit that represented an investment of $25,000, is now entrusted with the responsibility of handling a single boiler unit that may involve as much as a quarter of a million dollars. Greater investment means greater responsibility, which in turn, necessitates greater operating care. Because of these facts, it cannot be overstressed that in a new installation, the boiler and furnace should be thoroughly dried out, and the internal surfaces boiled out with a solution of soda ash. The purpose of this is to remove any oil deposits that may have been left in the boiler during the manufacturing and erection periods.

Steam Generators

To dry out and warm up steam generators check inside the boiler drums carefully, to make sure that there are no obstructions.

Check inside the furnace to make sure there are no obstructions, such as wooden platforms, etc.

Fill the boiler with raw water, allowing a good portion to run out the blowdown valves, to wash out any dirt or mill scale that may be in the boilers.

Put the required quantity of soda ash and caustic soda solution in top drums, distributing along the length of the drum, then close drums ready for starting, adding additional water to bring up water level to the proper height.

J. L. MASSIE

a veteran of submarine service in the First World War, for the last 17 years heading-up the Southwestern division of the Henry Vogt Company, has come up with some timely hints for boiler plant owners.

Build a slow wood fire in bottom of furnace, on both sides of furnace, if possible, for distribution of heat, utilizing natural draft only.

Keep this fire going continuously for a minimum of 48 hours, and during this period keep drum vents and superheater drains open.

Maintain only enough fire in the furnace to bring up the heat, but not enough to generate any pressure.

After the drying-out period, close vents and drains, and bring boiler pressure up to about 10 or 15 lb., with one of the regular burners, and hold the boiler at this pressure for about 8 or 10 hours. During this time, the vent can be opened periodically to allow steam to escape, and assist in the boiling action.

Allow the boiler to cool for about a day, or until the temperature is sufficiently low to allow complete drainage and flushing of the inside boiler surfaces, by hand hose if possible, and keep flushing until clean water begins coming out of the blowdown.

Add chemicals for initial operation of boiler, close drums, and fill the boiler to proper level.

During the drying or warming up period, the exterior of the boiler and furnace should be carefully examined to detect any openings that might be caused by expansion. Any openings that develop in the setting around drums or headers should be closed with flexible insulation to prevent air infiltration. Also watch for any undue strains that might be set-up on the connecting boiler piping.

Make sure the boiler vent is open, and make sure that the superheater drain is open, and that there is no water in the superheater.

Check the furnace to make sure that proper draft is available, and no fuel has escaped into the furnace.

Start induced-draft fan, and purge furnace, and keep fan running slowly, to obtain just enough draft to maintain combustion.

Bringing-up a Boiler

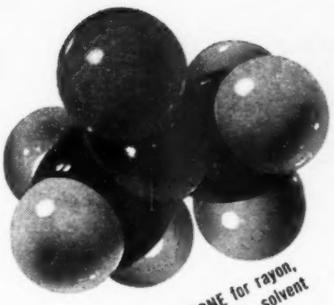
When bringing-up a boiler make sure the feedwater pumps are operative. See that all steam, fuel, and blowdown valves are closed and feedwater valves are operative; check water columns, and open the superheater drains and vent on the boiler steam drum.

The boiler will be brought-up on natural draft. Open the uptake dampers, or damper on the induced-draft fan, whichever the case may be; close any bypass dampers that may be installed in any bypass arrangement around preheaters, or economizers.

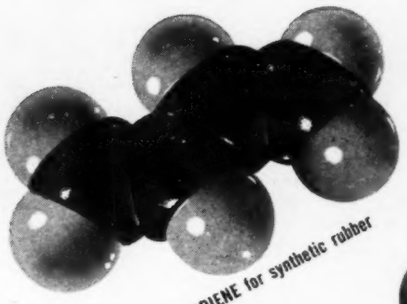
Do not attempt to light a burner for at least two minutes. Air should be circulated through the furnace and passed to the stack during this time, in order that any combustible gas within the setting will be removed. This precaution is necessary to prevent explosion of the gases that may have accumulated since the boiler was last in service, or during the starting-up period.

See that the water is showing in the water column; about 2 in. is the correct level when the boiler is cold. If the boiler water is too high, blow-down to proper level in glass.

See that all burners are properly clamped in place, and that burner connections are tight. Using natural gas as fuel, insert a lighted torch with a substantial wick, at the flame tip; open the stop cock at the gas burners, then crack



ACETONE for rayon, photo film; solvent



BUTADIENE for synthetic rubber

ETHYL ACETOACETATE for life-saving drugs, vitamins

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AVOID this Costly Valve Leakage

AREA OF LEAK	AIR		STEAM		WATER	
Diameter Inches	Number of cubic feet per month at 75 lb. pressure	Total cost of waste per month 11c per 1000 cubic feet	Pounds wasted per month at 150 lb. pressure	Total cost of waste per month 65c per 1000 lb.	Gallons wasted per month at 60 lb. pressure	Total cost of waste per month 16c per 1000 gallons
1/2"	13,468,000	$1,481.44	1,219,280	$792.53	1,524,100	$243.86
3/8"	7,558,500	831.44	684,290	444.79	855,360	136.86
1/4"	3,366,990	370.37	304,820	198.13	381,020	60.96
1/8"	824,570	90.70	74,650	48.52	93,310	14.93
1/16"	213,000	23.43	19,280	12.53	24,110	3.86
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Enlarged copies of this chart on request; also ask for Catalog 78.

Valves aren't easy to replace these days . . . practically all materials going into their manufacture are on the critical list. This means that it is up to every valve user to take the best care of what he has, to insure the longest possible service life.

Leaky valves are saboteurs of your production schedules . . . obstructing your best efforts and increasing your costs. The chart illustrated above gives you an idea of what valve leakage costs you, not to mention the lowered efficiency of your operations.

Fortunately, valves respond to good treatment. Careful handling, immediate repair of the slightest leaks, and prompt replacements of worn parts will keep them on the job, ready to meet the demands imposed by industry's unprecedented war effort.

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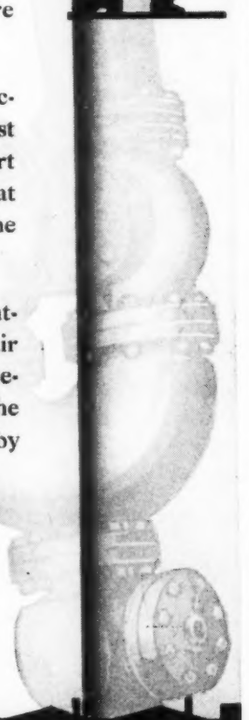


LUNKENHEIMER VALVES

the individual stop valve behind the cock, and open burner damper.

As soon as the flame is caught, gradually open the fuel stop valve and damper, to get a medium-sized stable flame. Follow the same procedure as additional burners are added.

The first burner lighted preferably for distribution, should be the bottom center burner, and *do not attempt to light one burner from another.*

Two burners should be used for starting-up and operated with a medium flame, to bring up the steam pressure to 10 lb. in about three hours; hold pressure at 10 lb. for about two hours, and during this period, thoroughly check the boiler installations for any undue expansion, then slowly bring up pressure hourly at increments of 100 lb., checking expansion as pressure increases.

The vent on the boiler drum should be wide open when the boiler is zero gauge, and should be left wide open for at least 30 minutes after the boiler is steaming, in order that the non-condensible gases above the water level will be driven off.

When the steam pressure in the boiler rises to 10 lb., leave the outlet drain at the automatic non-return valve wide open, and close the other superheater drain valves. Reopen the drain at the superheater inlet approximately two revolutions, and leave it that way until the pressure in the boiler is within 15 lb. of the header pressure, at which time open the valve wide. Leave both valves wide open until the boiler is on the line, then close them. Having both valves open during this period will prevent wet steam from being carried through the superheater into the steam header.

During this period watch the water closely and blow down to the proper level if the water rises to within 2 in. of the top of the glass. This is important, as a sudden drop in the main steam header pressure below that of the boiler being brought-up would pull the boiler on the line with a consequent rise in the water level.

When the steam pressure in the boiler reaches 100 lb. slowly charge the steam header, if it is not already charged, and then open the automatic non-return steam stop, carefully checking the superheat during the starting period to prevent pushing the boiler too hard, with consequent burning of superheaters.

At least 4 to 5 hours will normally be required to bring a cold boiler on the line (the exception being when the boiler is having its initial trial run), two and one-half hours from bank at 100-lb. pressure, and approximately one hour from bank at 250-lb. pressure.

During this period the induced draft

has been started to obtain sufficient draft to maintain around 10 in. in the furnace, and when the boiler comes on the line, *but not before*, start the forced-draft fan and add burners as needed.

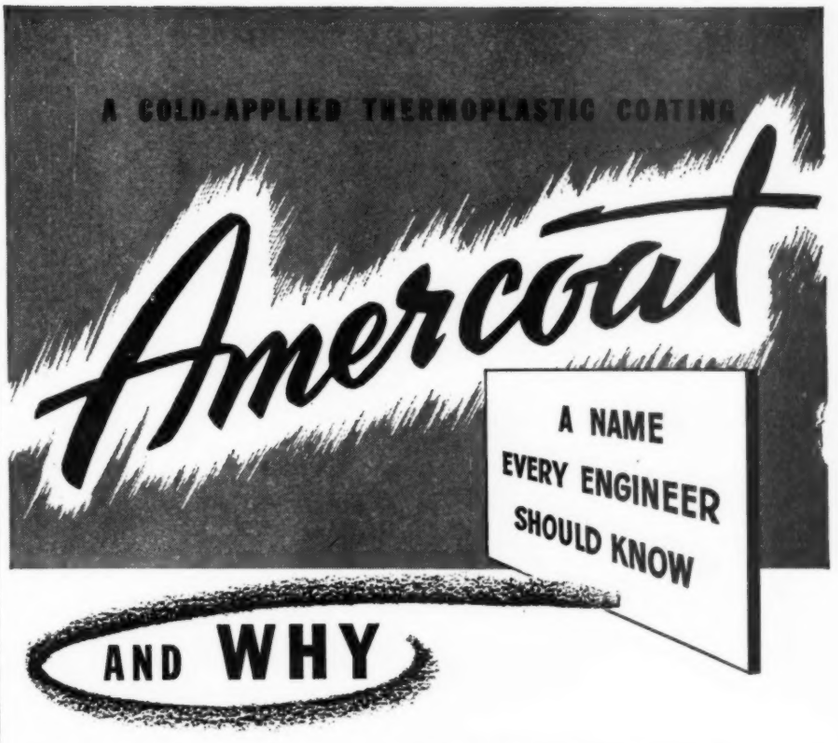
Boiler Operation

When the boiler is in operation:

1. Control feedwater flow by hand until the boiler is operating normally on line, then cut the feedwater regulation system.
2. Watch for flaming burners and see if it is getting sufficient air. Possible clogging of the tips may also cause trouble.
3. If using a Bailey Flow-meter, keep fins together, otherwise develop firing chart giving draft loss across burners to various gas pressure at burners. Use this, or some other means, to maintain correct combustion conditions.
4. If for any reason the feedwater temperature for which the unit is designed is lost, the superheat temperature will immediately begin to rise, and care should be taken that this temperature is not allowed to rise above the design limits of the superheater and turbine, and if necessary promptly take the boiler off the line.
5. Make routine inspection of outside of boiler to observe any unusual conditions, such as cracks in setting, water or steam leaks, etc.
6. Develop definite routine, watch procedure for boiler blowdown, and feedwater and boiler water sampling and testing.
7. Keep careful check on flue gas temperature versus steam flow, to make sure that the boiler surfaces are clean and the baffles tight. A table should be prepared when the boiler is new so that a standard set of conditions is formulated.
8. If the installation includes automatic control equipment, it is advisable to get the manufacturers service engineer initially to adjust the equipment, and train the operating personnel.

Removing Boiler from Service

To remove the boiler from service decrease the gas pressure in such a manner that the load can readily be shifted to the other boilers in service. Cut out the outside burners first, leaving the center burner until last. As each burner is cut out, close the individual air damper and pull the burner and deflector back as far as possible. (Pulling the burner and deflector back will prevent overheating.) Then crack slightly open the individual air damper to prevent heat from the furnace damaging the damper operating mechanism. When the steam flow on



Don't wait until you are face-to-face with critical problems concerning corrosion and contamination. Get the facts about *Amercoat* now!

Amercoat protects metal, concrete and wood surfaces from corrosion by many different acids, alkalies and chemical compounds now required in the manufacture of vital war and food supplies.

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Amercoat is impervious to the corrosive action of such varied materials as: Aviation Gasoline . . . Sea Water . . . Ammonium Nitrate Alcohol . . . 40% Formaldehyde . . . Lactic Acid . . . 50% and 75% Caustic Soda . . . Concentrated Magnesium Chlorid Brine . . . Drinking Water.

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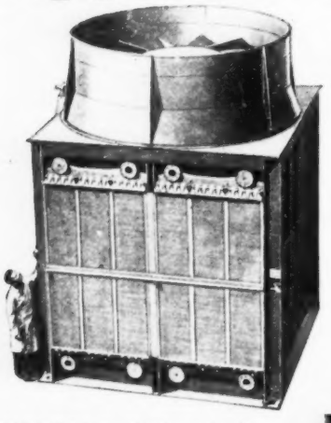
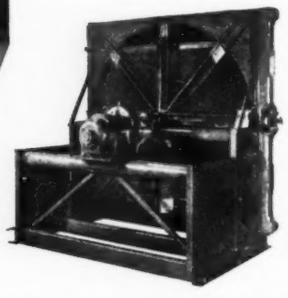


YOUNG *Quad Atmospheric* Cooling and Condensing Towers for large capacity vapor and gasoline and vapor mixture condensing; engine and compressor jacket water and lube oil cooling, and for gas cooling.



YOUNG Full-Flow jacket water, lube oil and compressed gas cooler and vapor condenser for installations with smaller capacities.

In the many refinery processes for the production of 100 octane gasoline, butane, the light hydrocarbon gases and other petroleum products, YOUNG *Quad Atmospheric* cooling and condensing towers are used for condensing vapors and cooling liquids and gases to approximate atmospheric temperatures. These YOUNG radiator type Coolers and Condensers utilize no spray water and no spray pumps, and tube bundle and shell heat exchangers are unnecessary, which cuts installation and operating costs. YOUNG equipment is engineered for maximum efficiency and trouble-free operation. There is no obligation for consultation with YOUNG engineers on your specific problems. Write for complete information.

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Temperatures below the ambient dry bulb can be maintained with *Quad Atmospheric* cooling towers in combination with YOUNG tube bundle and shell heat exchangers or YOUNG evaporative coolers. Evaporative coolers can also be used as complete cooling units.

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the boiler is approximately 35,000 lb. per hr., close the gas throttle valve at the front of the boiler, then close the stop cock at the burner header. (This will avoid having gas pressure in the header when this last burner is cut out.) Close all individual burner valves tight and open the ½-in. bleeder valve on the gas header, which will allow any gas remaining in the header to escape to atmosphere. If this were not done there would be danger of gas leaking into the furnace, thereby increasing the chances of an explosion. Close the windbox, downtake, uptake, and draft fan suction dampers. Stop the draft fan and shut off cooling water to the fan bearing. Close the hand feedwater valve. Maintain approximately 6 in. of water in the gauge glass while the boiler is banked near header pressure.

A higher water level in a boiler that is banked near header pressure is undesirable, as a sudden heavy pick-up in load, resulting in the main steam header pressure dropping below that of the banked boiler, would pull the boiler on the line, and hence wet steam or water into the turbine.

If the boiler is being removed from service for repairs, close the automatic non-return valve when the boiler pressure is low enough that the heat from the furnace will not raise the pressure to the set pressure of the valve.

Operation of Forced- and Induced-Draft Fans

Before starting a forced-draft fan, inspect the driver bearing oil cups to see that they contain oil; also inspect the gauge glasses of the two fan bearings to see that they contain ½ in. of oil. Refill to the proper level any bearings that are low on oil. Next, open the fan-bearing outlet cooling water valves wide open, and open the inlet water valves about one full revolution.

Open the fan outlet damper for desired air flow for starting-up, depending on the number of burners to be used, then open the fan suction damper wide open and use the discharge damper for air control.

The forced-draft fan driver *should never be started* until after the induced-draft fan is running and additional air is required for bringing burners on the line.

The inlet cooling water valves are to be kept closed on all draft fans not in service.

While the fan is in operation, observe whether the fires are steady; if fluttering occurs, this may be caused by too much or too little air, or a loose damper.

Check drivers and fans periodically for mechanical vibrations, and check bearing temperatures periodically for temperatures, according to the respective manufacturers recommendations, using when possible, oil as recommended by fan manufacturer.

Before starting induced-draft fans, open the bearing cooling-water valves sufficiently to pass a small stream of water. After the fans are started, adjust the valves so that a stream of luke-warm water passes. Inspect the fan bearings as well as driver bearings, to see that they are properly filled with oil.

Open dampers, start fan, and check periodically for bearing temperatures and general mechanical vibrations.

When operating preheaters of the Lungstrom type inspect the three roller bearings and the drive bearings on each preheater to see that the reservoirs have sufficient oil. Oil should be within ¼ in. of the top of the inspection cup. See that the sight feed oil cups for each preheater drive gear is filled and regulated, to feed one drop of oil in three minutes.

The preheaters are to be started before the boiler is fired; also before the induced- and forced-draft fans are put in service.

Check the preheater element and drive periodically when operating, for mechanical vibrations, and the elements for moisture formations caused by possible gas discharge temperature below, or approximating, dew point.

☆ ☆ ☆

New A.S.T.M. Standards Approved

By recent action of the Standards Committee of the American Society for Testing Materials, several important new standards have been approved. These are of concern in the fields of steel, rubber, and chromium plating.

For some time Committee E-3 on Chemical Analysis of Metals has been developing a standard method for determining selenium in steel. This element is used to improve machinability of certain steels including corrosion-resisting alloys, and with no recognized standard available chemists have been handicapped in determining the amounts present not only when the element is specifically added but also as it occurs in stray amounts. The new method just approved carries the designation E 30-43 T and makes use of the sulphurous acid-iodometric method; and although the standard is published for the first time, it is set up as a tentative revision of the widely used Standard Methods of Chemical Analysis of Steel, Cast Iron, Open-Heart Iron, and Wrought Iron (E 30-42). The new method will be issued in separate pamphlet form.

The new revision of the Tentative Method of Test for Changes in Properties of Rubber and Rubber-Like Materials in Liquids (D 471-40 T) is a most important addition providing urgently needed standardized procedures for determining volume changes of rubber, particularly the new synthetics on immersion in solvents. The new method is distinctly simpler and more rapid than the present procedure and gives comparable accuracy. The methods were first described by B. S. Garvey, Jr., in his paper in the *A.S.T.M. Bulletin*, March, 1941, page 19, covering "An Immersion Test for Rubber Compounds." The procedure used is quite accurate, fast, and is a really clever use of glass tubing, selected rubber samples, solvent, and method of measuring.

A.S.T.M. Committee B-8 on Electrodeposited Coatings has previously developed a number of important specifications covering various types of coatings on steel, copper, and zinc alloys and has developed the test for local thickness of electrodeposited coatings. Its most recent work has involved agreement on recommended practices for various types of plating and the new Tentative Recommended Practice for Chromium Plating for Steel for Engineering Use (B 177-43 T) is the first of a number of such standard practices that will be issued. The scope of the recommended practice is as follows:

"This recommended practice is presented as an aid to such platers and engineers who, although familiar with ordinary plating practice including decorative chromium plating, are confronted with new problems inherent in the deposition of chromium for engineering use. It is not intended as a standardized procedure but merely as a guide to the realization of smooth, adherent coatings of chromium of desired thickness and to the retention of the required physical properties of the steel base."

In this specification are discussed the nature of the steel with particular reference to its hardness, procedures for cleaning and etching prior to chromium plating, construction of racks and anodes, the chromium plating operation itself, subsequent treatments of the coating and repair of worn coatings, and finally test methods.

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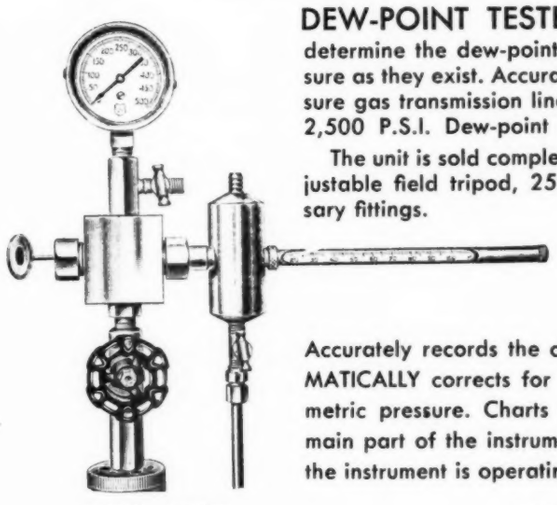

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DEW-POINT TESTER—With this tester it is possible to determine the dew-point of gases under conditions of pressure as they exist. Accuracy within 0.2° F. even on high pressure gas transmission lines. Built for working pressures up to 2,500 P.S.I. Dew-point temperatures as low as —90° F.

The unit is sold complete with hardwood carrying case, adjustable field tripod, 25′ of ¼″ copper tubing and necessary fittings.

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Accurately records the changing gravity of gas and AUTOMATICALLY corrects for variation in temperature and barometric pressure. Charts are changed without exposing the main part of the instrument. Record completely visible while the instrument is operating.

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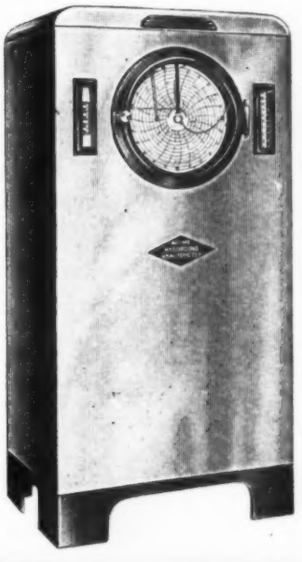

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FROM WASHINGTON

Ickes Urges Indiana Conservation Law

Petroleum Administrator for War Harold L. Ickes recently expressed the hope that the State of Indiana would enact a proper oil conservation law at the earliest opportunity.

The hope was voiced in a letter to Hugh A. Barnhart, Director of the Indiana Department of Conservation, who had written the Administrator to advise him of the recent failure of the Indiana General Assembly to enact legislation providing for the regulation of the oil and gas industry in that state.

Administrator Ickes wrote Barnhart that he found it difficult to understand how those opposed to the legislation had been "able again to defeat a measure of a type that is so essential to the well-being and the best interest of a great state."

"You and I do not have to argue the merits of this case," the letter continued. "We know that conservation, as it now exists in the various states that have it, is a result of state legislation and state administration based on the practical test of experience. It has served the public interest and individual interest as well.

"We do not have to be geologists or petroleum engineers to understand that an oil field, whatever its origin, represents a slow accumulation which must have required geologic time rather than measurable years to reach its present state, and that even our best efforts at more efficient withdrawal of the oil must be relatively disturbing as compared with the slow and orderly processes of nature which resulted in the formation of the deposit. Oil floats on water and oil deposit might well be compared to the cream which floats upon a pan of milk. No housewife is so stupid as not to realize that any quick and violent attempt to skim the cream can only result in turbulence and greatly reduced recovery.

"That the legislators of your state should have succumbed to the same strategy and the same misguiding leadership which defeated efforts to get a decent conservation law in your neighboring and my home state of Illinois is not easy to understand. Indiana had before it the example of Illinois where, by gold-rush tactics characteristic of the worst open-flow days of the oil industry, production went from a little more than 10,000 bbl. daily in early 1937 to more than 500,000 bbl. daily in mid-1940, down to 345,000 bbl. daily in 1941, back to 422,000 bbl. daily in late 1941, and is now at the way station of 240,000 bbl. daily on a long decline. I predict that within the brief period of 10-12 years, the Illinois oil industry will have gone from rags to riches and back to rags again. All of this will have been accomplished while approximately one billion barrels of oil are being produced. A few buccaneers will have made fortunes but the average oil producer, the average land-owner, and the state will have realized much less profit than they would have realized under orderly development. Moreover, the public will be poorer by the 300,000,000 to 500,000,000 bbl. of oil which might have been recovered if well drawn and properly administered conservation laws had been in effect.

"Should we be so fortunate as to discover new pools of great capacity in your state, I can assure you that the bank-run pattern of Illinois development will not be repeated in Indiana during my tenure as Petroleum Administrator for War. The nation cannot afford such another spree. Beyond that, I can only hope that wiser counsel will prevail in your state in the future, and that it will provide itself with a proper conservation law at the earliest opportunity.

"I am grateful for the support of the conservation principle which has been given by the Governor, those legislators who supported it, yourself, and the members of the industry. I am particularly appreciative of your determination to do everything within your power to conserve these important natural resources and of the continued co-operation of your Department."

Gallagher Granted Authority

Administrative authority over certain aspects of oil production operations on the West Coast has been delegated to Herbert R. Gallagher, District Director in Charge of PAW's West Coast district, Petroleum Administrator for War Harold L. Ickes has announced.

The announcement was made to coincide with the issuance of an amended Supplementary Order No. 4 to Petroleum Administrative Order No. 11, which outlines the standards and conditions for the conduct of development and production operations in substantially all California oil fields. The effect of the delegation is to give Gallagher authority to do the following things under PAO No. 11:

1. To grant exceptions for the drilling of new wells in certain pools, permitting a reduction in the size of the drilling unit down to the number of acres specified in a schedule attached to the delegation of power.

2. To grant exceptions with respect to certain pools, permitting a reduction of 10 percent in the drilling unit area or well density prescribed, or

a reduction of 20 percent in the required distances between well locations. The power to grant exceptions of this class is limited to cases where extraordinary and unusual topographic conditions make it advisable.

3. To grant exceptions, under certain limiting conditions, with respect to a new well in a "town lot" field.

4. To grant exceptions, again under certain limiting conditions, with respect to operations involving the recompletion of a well by perforating, plugging-back, deepening, or redrilling of an existing well in any pool other than that in which the well was last completed.

5. To require operators to file with the PAW District Office, prior to the beginning of a production operation in California, a copy of such official form as is required to be filed under the state law of California in connection with such operation.

6. To deny any application for exception, subject to the right of the operator to appeal to the PAW Washington Office.

7. As Director in Charge, Gallagher may redelegate these powers to Lawrence Vander Leck, district director of production, with respect to production operations, and to Kenyon L. Reynolds, district director of natural gas and natural gasoline, with respect to natural gas, natural gasoline or condensate operations.

Post War Planning Committee Report

Development of the necessary factual information needed as a basis for the study of petroleum industry post-war problems will be the first concern of the Petroleum Industry War Council's subcommittee on post-war problems, William R. Boyd, Jr., Council Chairman, has announced. Offices for the subcommittee have been opened in the Union Commerce Building, Cleveland, under the direction of the chairman, Paul Ryan.

In a brief report to the Council's April meeting the subcommittee announced its plan to consult with groups comprehensively representing various branches of the industry concerned as their studies on any of the important post-war problems progress. They asked to be informed of any prospective discussions by trade associations and other industry groups who plan discussions of post-war problems.

Tubular Goods Inventories in Field

Establishment of mill stocks and field depots of oil-country tubular goods to eliminate present delays in obtaining pipe for drilling oil wells has been recommended to the Petroleum Administration for War and the War Production Board by the Petroleum Industry War Council.

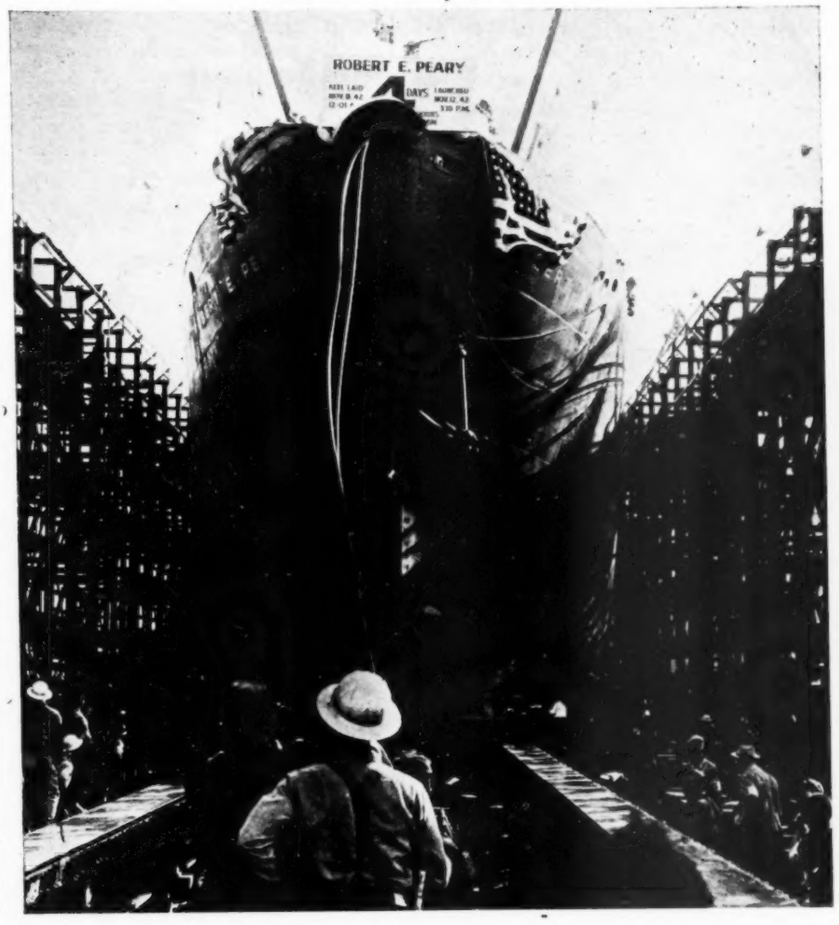
Oil-well drillers are experiencing long delays in shipments of pipe after government approval of purchases, and they no longer have any inventories of their own from which to draw. The War Production Board was asked to authorize establishment of stocks both at the mills and at field depots near centers of oil production, the stocks to be subject to control by the Petroleum Administration.

Edward Longstreth Award

The invention of the Hydromatic brake is universally regarded as one of the most revolutionary advances of modern times for the drilling of deep wells, and for its development Robert Griffin De La Mater and William Schwemlein, of Parkersburg, West Virginia, were awarded Edward Longstreth Medals jointly at the annual Medal Day exercises of The Franklin Institute, Philadelphia, held April 21.

Within the last few years practically every deep well in this country and abroad has been drilled with the aid of this device, which is manufactured by the Parkersburg Rig and Reel Company, and the efficiency of its operation has caused the Hydromatic Brake to be regarded as standard equipment by virtually every major oil company.

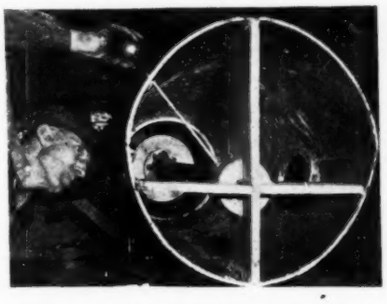
Less than 5 Days
FROM KEEL LAYING TO LAUNCHING



One of the greatest blunders in history was the Axis' failure to evaluate American capacity to produce unheard of quantities of vital war material and the cargo ships required to get that material to fighting fronts . . . *in a hurry.*

We at Oil Center like to feel that the job we are doing for the U. S. Maritime Commission is contributing materially to the saving of precious shipbuilding time and to the defeat of our enemy.

When the war is won, look to O-C-T for even better oil tools made possible through experience gained from precision machining practices and improved metallurgy.



Here is a difficult horizontal boring mill job being done with precision on an engine lathe because Oil Center did not have a horizontal boring mill. Raising blocks lifted the spindle so that the job could be mounted on the carriage. I-beams provided a foundation on which to clamp the job. it can be done if there's a will to do it!

O-C-T proudly flies the prized Treasury Flag.

QUALITY O-C-T PRODUCTS
"Selling Through Leading Supply Stores"

OIL CENTER TOOL COMPANY
HOUSTON, TEXAS, U·S·A
Export Representative: Val R. Millich, 30 Rockefeller Plaza, New York, N. Y. ● Oficina de representaciones extranjeras: Calle Lavalle 710, Buenos Aires, Argentina.

A.S.T.M. Committee Meets

AT THE recent meetings of Committee D-2 of the American Society for Testing Materials, on Petroleum Products and Lubricants, in Cleveland, a number of actions were taken that will eventually affect the various standards and proposed standards in the province of the committee. Many of the actions affecting standards must be confirmed by letter ballot before formal recommendation is made at the A.S.T.M. annual meeting in June.

In order to elicit comments and suggestions on various proposed test methods, the committee has frequently had these published as information only in its reports and its special compilation on petroleum products and lubricants. Several are included in the current compilation, including a procedure for determining percentage of oil in paraffin wax having a melting point of 105° F. or higher, and containing not more than 10 percent by weight of oil. There has been considerable interest in this test and it is proposed as a tentative standard. Some of the members have found the method useful beyond the intended scope in determining the oil content of slack waxes and petrolatums, and these applications are to be investigated.

The newly organized Subcommittee XXIV on Petroleum Sulfonates reported on the initial coöperative work comparing several proposed methods under consideration. The results so far reported were not sufficiently conclusive to permit presenting a method for consideration prior to the annual meeting of the Society.

The committee recommended that the present Tentative Methods for the Carbonizable Substances in White Mineral Oil (D 565) and Carbonizable Substances in Paraffin Wax (D 612) be adopted as standards, as the methods have been found to be entirely satisfactory. The two methods are intended to ascertain whether the oil and wax conform to the standard of quality for pharmaceutical use.

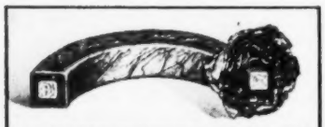
Another proposed method published as information on the recommendation of the committee involves a procedure for oxidation of heavy-duty crankcase oils. In the test the lubricant is evaluated only with respect to stability or resistance to oxidation, bearing corrosion, and the deposition of intrinsic contaminants resulting from decomposition, oxidation, or other changes that occur in the lubricant in service. There was considerable interest indicated at the meeting in one of the appendices of this test covering insoluble matter in used crankcase oils. This is intended for the gravimetric determination of the naphtha-insoluble matter and the naphtha-insoluble matter soluble in chloroform, in used crankcase oils. The committee plans to recommend that the test for oxidation characteristics be issued by A.S.T.M. as an emergency test.

Recently there has been considerable activity involving tests for neutralization and saponification number—Method of Test for Neutralization Number of Petroleum Products by Color-Indicator Titration (D 663—42 T), and Method of Test for Neutralization Number of Petroleum Products by Electrometric Titration (D 664—42 T) having been issued last year and Method of Test for Saponification Number of Petroleum Products by Color-Indicator Titration (D 94—42 T) was also published. It was reported that Subcommittee XIII on Neutralization Number and Saponification had developed an additional saponification number test making use of the electrometric method, which will be recommended for publication and information and to solicit comments.

At the meetings, there was presented for information the results of the cooperative work to correlate the results of the A.S.T.M. bomb test with actual storage stability of gasoline.

The Technical Committee on Turbine Oils voted to publish as information the progress to date with regard to formulation of a method for the determination of the oxidation characteristics of turbine oils.

DURAMETALLIC PACKINGS *are Engineered for the Job*



THE DURAMETALLIC TWIST

1. Processed to retain lubrication.
2. Provides readier response to gland pressure.
3. Distributes frictional load over several diagonally wrapped metallic sheets.
4. Originated by DURAMETALLIC.

Any user of Durametallic Packings will tell you that it pays to use the right type of packing to meet the need. The more difficult the problem, the greater the chances are that you need DURAMETALLIC PACKINGS to provide effective sealing for longer uninterrupted runs.

The PERFECT SEAL

DURAMETALLIC CORPORATION

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HOUSTON . LOS ANGELES . CHICAGO . NEWARK . NEW ORLEANS
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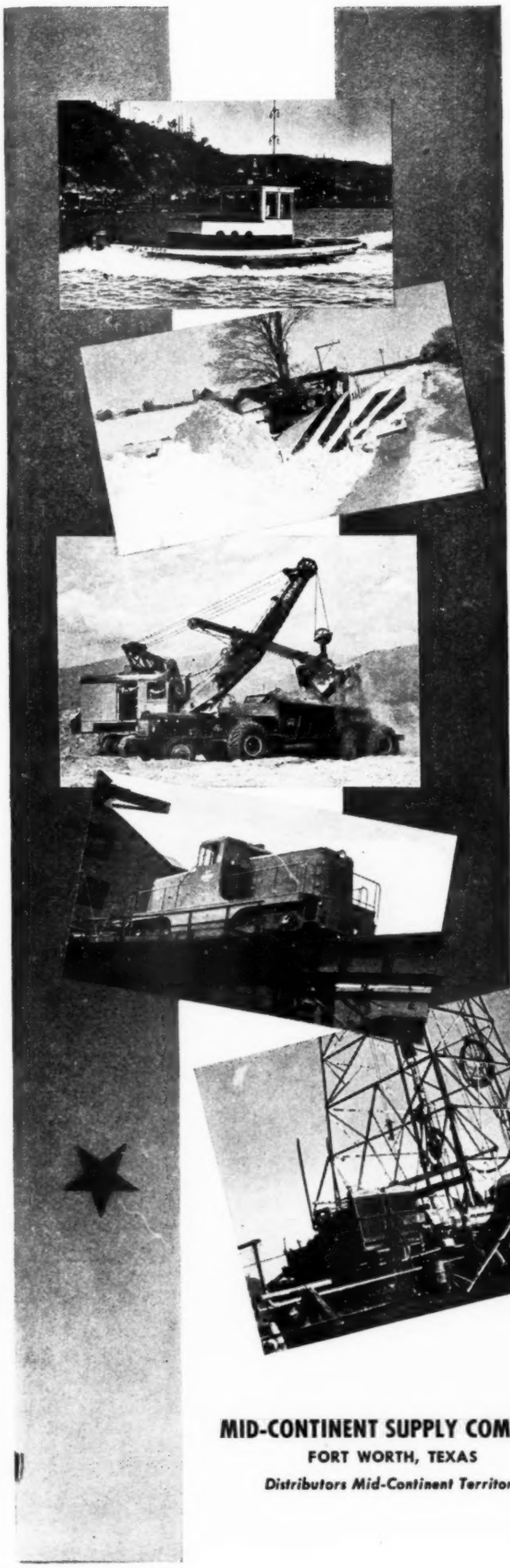


At its best . . . when the going is

Tough

The first Cummins high-speed Diesel was offered to the public in 1932. From that day to this, the Cummins Diesel has never asked for the easy jobs . . . but has consistently proved itself in the face of the longest odds . . . on the toughest, the longest and the hardest pulls . . . on the jobs which demand the delivery of an engine's full rated horsepower day after day.

Now, after a decade of conditioning, the Cummins Diesel is ready for action—*is in action*—on every front in this global war. Its quick starting has been tested in the sub-zero arctic cold. Its cool running has been demonstrated in flaming desert heat. Its simple, easy service and maintenance has been proved in the world's most inaccessible, out-of-the-way places.

In short, the Cummins Diesel has proved its ability to uphold the highest American tradition . . . to do its best job when the going is toughest. CUMMINS ENGINE COMPANY, Columbus, Indiana.

Out of the experiences of owners during the past 10 years—plus new tests which the engine is meeting daily—a newer and better Cummins Diesel is now building . . . one which will do your job at a lower cost, for a longer time, with fewer parts replacements and service requirements. When all-over economy again becomes the yardstick of value, this new Cummins Diesel will be your first choice. The new booklet, "Threshold to the Future" will tell you why. Ask for your copy.

MID-CONTINENT SUPPLY COMPANY
FORT WORTH, TEXAS
Distributors Mid-Continent Territory

CUMMINS
Dependable
DIESELS

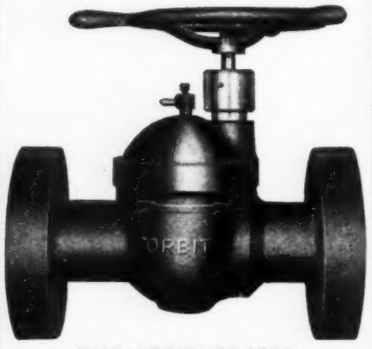
OIL WELL IMPROVEMENTS CO.

Pioneer creator and manufacturer of drilling and producing equipment, has been in the

FIRST LINE
of the Oil Industry's
Production Front

Now . . .

OWI products are serving in the
FIRST LINE
of the Navy's
Destruction Front



THE ORBIT GEARED MASTER VALVE

And while most of our production facilities are devoted to vital production for our fighting Navy, we will continue to furnish Orbit Valves to the Oil Industry to the limit of our ability.

If you have any questions regarding the care and maintenance of your Orbit Valves, write us.

OIL WELL IMPROVEMENTS CO.
TULSA, OKLAHOMA

Running Tour

WITH MEN IN THE INDUSTRY

PAUL ENDACOTT was named vice-president and assistant to the president at the annual stockholders meeting of Phillips Petroleum Company in Tulsa. W. G. HIATT was elected vice-president of the refining division and T. S. GAY was appointed assistant secretary and manager of the New York office.

E. C. GRANDIN

ELLIOT C. GRANDIN has been appointed general sales manager and GEORGE C. JOHNSON, assistant sales manager of the Titusville Forge Division of Struthers Wells Corporation, Titusville, Pennsylvania. Grandin is also manager of the Ordnance Division of the Corporation.

W. T. SHINHOLSER has been appointed chief engineer for all divisions of Ohio Fuel Gas Company, Columbus, Ohio. Shinholser has been connected with the gas business for 26 years.

ORVILLE O. KERR, Tulsa, Oklahoma, secretary and treasurer of the Deep Rock Oil Corporation, has been named director to succeed the late William R. Francisco, executive vice-president. ALEX W. MCCOY, manager of the land and exploration department, was promoted to the position of vice-president in charge of land and exploration.

OTTO D. DONNELL, president of the Ohio Oil Company, has been appointed chairman of the petroleum industry general committee for the mid-western states—District 2 of PAW. He succeeds FRANK PHILLIPS, who resigned because of ill health.

HY BYRD has been appointed vice-president and treasurer of Panhandle Eastern Pipe Line Company. Byrd was formerly vice-president and assistant secretary of Phillips Petroleum Company.

K. S. ADAMS, president of Phillips Petroleum Company, Bartlesville, has accepted the appointment by Governor Robert S. Kerr as chairman of the Oklahoma post-war planning commission and vice-chairman of the state planning and resources commission.

FRANK P. PETERSON, retired assistant manager of production, Mid-Continent Petroleum Corporation, Tulsa, Oklahoma, was presented with the Hanlon Award at the convention of the Natural Gasoline Association of America held in Dallas, Texas. The award, which is the highest in the natural gasoline industry, is given each year. Peterson did pioneering work in the industry, discovering principles of gas testing, analysis, and manufacture that are the basis of present methods.

CHARLES A. BUTCHER, formerly assistant to the national manager of Westinghouse Electric and Manufacturing Company's district manufacturing and repair department, has been named manager of that department for the Pacific Coast District. Butcher will make his headquarters at Emeryville, California, from where he will direct his department, which covers 11 western states, Alaska, and the Hawaiian Islands. A graduate of Iowa State College in electrical engineering, Butcher joined Westinghouse in 1917 and has served in various capacities for the company since that time.

JACOB FRANCE, president of the Mid-Continent Petroleum Corporation, Tulsa, Oklahoma, observed his 25th anniversary as a D-X worker last month. The occasion was celebrated at a 20-year club meeting where he was presented with a medal.

HILLARD W. CAREY has accepted a position as head of a new production engineering department for the Houston Natural Gas Corporation, Houston, Texas. Carey has been chief geologist for the Halliburton Oil Well Cementing Company and associated interests for the last ten years. He joined the Halliburton organization immediately after graduating from the University of Oklahoma in 1933. The new department of Houston Natural Gas Corporation will be devoted to specific phases of production, engineering, and geological work.

J. E. MCFATE has been appointed manager of tubular sales of the Republic Supply Company with office at Houston, Texas. McFate was formerly with Republic Steel pipe division.

GLENN A. CAMPBELL, Tulsa, Okla-

homa, has been appointed senior petroleum production analyst for the Petroleum Administration for War, and assigned chief of the priorities unit of PAW at Washington. Campbell is a drilling contractor and oil operator and is vice-president for rotary drilling of the American Association of Oilwell Drilling Contractors.

ADRIAN MOORE, independent drilling contractor and oil operator, Houston, Texas, has been appointed to the post of district director of production for the Petroleum Administration for War in the Southwestern states. Moore succeeds E. O. BUCK, who resigned to become superintendent of operations for the Rowan Brothers Drilling Company, Fort Worth.

HARRY WHEELDON of Dallas, Texas, has been appointed superintendent of gasoline plants for Lone Star Gas Company and Lone Star Producing Company, to succeed the late J. R. JARVIS. FRED TOWNSEND, superintendent of

HARRY WHEELDON

gasoline plants in East Texas, will be his assistant. Both men are graduates of Texas A. and M. College in chemical engineering. Wheeldon joined Lone Star upon graduation in 1922 and has worked in most of the company's major plants. Townsend became a member of the organization in 1927.

DR. ROBERT V. YOHE has been appointed plant manager of the government synthetic rubber plant operated by B. F. Goodrich in Kentucky. Entering the rubber industry in 1931, Yohe has held research and production positions in various divisions of the B. F. Goodrich Company. The post in Kentucky was formerly held by J. W. FRASCHE, who has been named plant manager at another government synthetic plant in Texas, which will also be operated by Goodrich. DR FRANK K. SCHOENFELD has been named technical superintendent of the chemical division to succeed Yohe.

Waste in the oilfields can mean shortages on the battlefields . . . so conservation of equipment is one of your most vital wartime duties. Better equipment to start with is one way to conserve.

Spang Cable Tools, made under "The Higher Standard," are your best bets for long life and efficiency under the most severe working conditions.

SPANG & COMPANY, Butler, Pa.

SPANG

THE BIGGEST NAME IN

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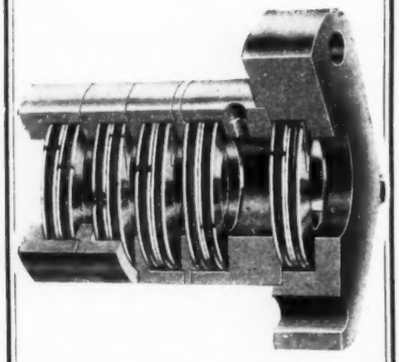
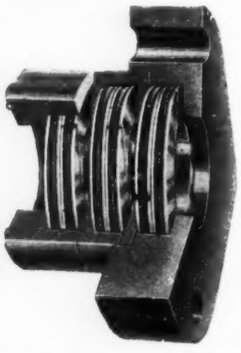
KEEP 'EM HUMMING!

√ Compressors
√ Engines
√ Pumps



Type No. 270. Designed especially for gas compressors. France Metal "Full-Floating" Packing is outstanding for its long wearing qualities. Eliminates frequent shut-downs.



Type No. 190. Designed for shallow stuffing boxes. Prompt delivery assured.

Specify the packing that L-A-S-T-S — FRANCE "Full-Floating" Metal Packing. *Ask for catalog No. M-3.*

THE FRANCE PACKING COMPANY
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Mid-Continent Representative:
MR. J. M. FULLER, 3725 W. 7th St.
FORT WORTH, TEXAS

Original FRANCE METAL PACKING

LAUGH WITH BARNEY

Husband (answering telephone): "I don't know. Call the weather bureau."

Pretty Young Wife: "Who was that?"

Husband: "Some sailor, I guess. He asked if the coast was clear."

* * *

A New York City lawyer once defined "horse sense as the kind a jackass hasn't got."

* * *

There are three kinds of modern warfare. Offensive, defensive and the Italian kind—inoffensive.

* * *

A bishop attended a banquet and a clumsy waiter dropped a plate of hot soup in his lap. The clergyman glanced around with a look of agony and exclaimed:

"Will some layman please say something appropriate."

* * *

"How did you cure your husband from staying late at the club?"

"When he came in late one night, I called out, 'Is that you, Jim?' and my husband's name is Frank."

* * *

A wedding carriage was seen driving through the streets of London the other morning. Inscribed in chalk on the back were the words "Result of Careless Talk."

* * *

Birmingham police radio droned this order: "Car X-Y, go to Third Avenue and 14th Street. A nude woman running down the street." Then, an afterthought: "All other cars remain on your beat. That is all."

* * *

One supply company sent a dumb cluck out after an eight-inch nipple and they found him later in a burlesque show.

* * *

He: "If you don't let me kiss you, I'm going away."

She: "Go as far as you like."

* * *

"What is your rank?" a sweet young thing asked a sailor.

"Ship's optician," he replied.

"I didn't know there was such a rank," she said. "What are your duties?"

"Scraping the eyes of potatoes."

* * *

"Tell me one thing chemistry has given to the world."

"Blondes."

Sentry: "Who goes there?"

Major: "Major Jones."

Sentry: "I can't let you proceed without the password, sir."

Major: "Drat it, man, I've forgotten it. You know me well enough."

Sentry: "Must have the password."

Voice from guardhouse: "Don't stand there arguing all night; shoot 'im."

* * *

Brash Mr. Smith was crossing a pasture.

"Say, there," he shouted to a farmer, "is this bull safe?"

"Well," said the farmer, "I reckon he's a lot safer than you are just now."

* * *

Customer: "Is this candy good?"

Clerk: "As pure as the girl of your dreams, my lad."

Customer: "I'll have some chewing gum."

* * *

He: "There is a certain reason why I love you."

She: "My goodness!"

He: "Don't be absurd."

* * *

One Broadway wit was asked to define point rationing. "It's easy," he says. "You point to what you want, and the grocer says you can't have it."

* * *

A northern tourist was visiting the little cabin of an ancient darky known as Uncle Mose, who lived in a small Virginia town, and who often entertained visitors with stories of the "War Between the States."

"I understand you remember seeing Lincoln," the visitor remarked.

Uncle Mose looked sheepish. "No, suh," he replied. "Ah used to 'member seeing Massa Linkum, but since Ah j'ined de church Ah doan' 'member seein' him no mo'."

* * *

A man going down the street met a friend he had not seen for some time. During the course of the conversation this friend seemed to be in pain. When asked what the trouble was he replied that his feet hurt because his shoes were too short. When asked why he did not get larger shoes, he replied that his wife had run away with the chauffeur, his son was in jail, his daughter married a ne'er-do-well, he had lost all he had in the stock market and now the one pleasure he got from life was to take these tight shoes off when he got home in the evening.

BAKER OIL TOOLS, INC.

BAKER MODEL "K" CEMENT RETAINER

A-21

Reasons Why the Baker Cement Retainer is "First Choice" for Cementing, Well Repair and Well Completion Operations

Main Office and Factory:
6000 So. Boyle Ave., Box 127, Vernon Station, Los Angeles, Calif.
Central Division Office and Factory:
6023 Navigation Blvd., Box 3048, Houston, Texas
Export Sales Office:
19 Rector Street, New York, N. Y.

250.1
May, 1943
1 of 1 p.

USE IS PROOF

The Baker Model "K" Cement Retainer has been used successfully in thousands of oil wells in fields throughout the world. The original Baker Cement Retainer was invented (and the name "Cement Retainer" coined) some 30 years ago and the present tool embodies the knowledge and experience gained during that time in both manufacturing and running many Cement Retainers.

It is this accumulation of skill and experience that goes with every Baker Cement Retainer run into the hole today, and is the reason why this device is "first choice" for present-day cementing, well repair and well completion operations.

Competent Baker men will service, make suggestions, and otherwise assist in securing best possible results.

Baker Model "K" Cement Retainer (with Circulation Joint)

Provides a safe, sure means of placing cement through tubing or drill pipe at the place where it will be most effective, at any pre-determined point behind casing or liner; or around the shoe. It is adaptable to any pressure within the safety factor of the casing.

APPLICATIONS

POSITIVE BACK-OFF

There are two important construction features which assure positive sealing against casing and eliminate any possibility of fluid by-pass. Tool is hydraulically tripped and when set, the oil resistant packing forms a positive seal against the casing. One feature is the provision of a lead ring on either end of the packing member, which, when the latter is expanded, hermetically seals the ends of the packing, preventing any possibility of fluid by-pass. The second important feature is the use of flow stop discs, small metal discs located in the body of the Retainer underneath the packing. These discs act as valved fluid ports and prevent any flow of the packing into the Retainer Body when the packing is compressed.

RETAINER WILL STAY WHERE SET

Two sets of annular, segmented wickered slips prevent movement of the tool, once it is set, either up or down the hole.

EFFICIENT BACK-PRESSURE VALVE

The Ball Back-Pressure Valve, which becomes operative immediately after retainer is set, prevents return or equalizing of the slurry.

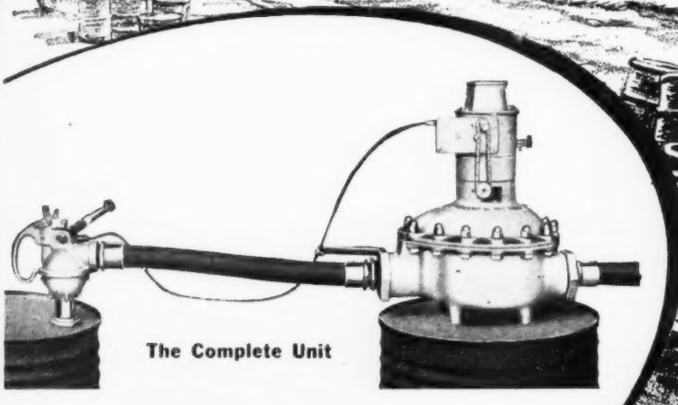
FLUID CAN BE BLED OFF

At any time during circulating or cementing operations, fluid can be by-passed through Circulation Joint, which is run just above the Cement Retainer.

HIGH PRESSURE POSSIBLE

The Baker Cement Retainer will safely withstand any pressures that can be imposed within the safety factor of the casing in which it is set.

Don't Hold Them Back



The Complete Unit

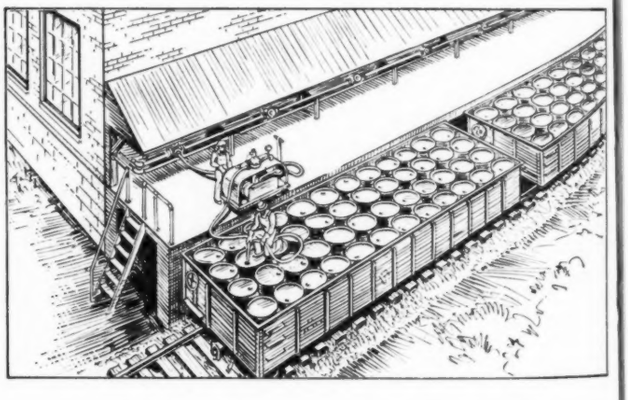
Consists of an Empire oscillating piston, positive displacement meter; a thermostatic microset for automatically correcting the meter measurement to the exact equivalent of the desired volume at 60° F.; a repeat register with exterior mounted quantity chain having a fixed cam thereon which trips a mechanically operated control valve with non-foaming dripless nozzle of integral construction.

Fill Drums ACCURATELY and RAPIDLY with the

EMPIRE *Thermostatic* DRUM FILLER

DRUMS to the rescue, on the war front and the home front! The unprecedented demands for gasoline and oil, the shortage of tankers and the danger of submarine attack on slow-moving, cumbersome ships, have all combined to place important emphasis on drummed fuels.

With the Empire Thermostatic Drum Filler, these drums of war can be speedily, accurately filled. The exclusive portable feature permits bringing the filler to the drums, rather than the drums to a central filling point. Accuracy is certain, since the automatic thermostatic control assures that the drumming is done to the exact equivalent of the desired volume at 60° F. Entirely automatic operation without manual control provides a new high in speed of filling. Measurement by the time-proven Empire Oscillating Piston Meter is always accurate. Chain cam-operated control permits rapid change from one predetermined delivery amount to another, by simply substituting the proper length quantity chain on the unit. Chains in delivery cycles of from 5 to 100 gallons can be furnished.



The sketch above indicates the manner in which a large midwestern refinery is speeding up drum filling through use of the Empire Thermostatic Drum Filler. Gondolas containing empty drums are spotted along the loading platform and the drums are then filled without removal from the cars. The Drum Filler is mounted on a hand truck for easy portability. Conveniently spaced outlets from the pipe-line along the platform wall, controlled by Nordstrom three-way valves, permit quick hookups to be made at any location. This same system can also be used for filling rubberized cells in box cars.

PITTSBURGH EQUITABLE METER COMPANY

NEW YORK · BROOKLYN · DES MOINES · MEMPHIS · OAKLAND · TULSA · CHICAGO · BOSTON

MERCO NORDSTROM VALVE COMPANY
Main Offices, Pittsburgh, Pa

NATIONAL METER DIVISION, Brooklyn, N. Y.

KANSAS CITY · PITTSBURGH · SAN FRANCISCO · LOS ANGELES · SEATTLE · HOUSTON · COLUMBIA · BUFFALO

INVEST TODAY IN BONDS FOR VICTORY

Meters

THE *Petroleum* Engineer's

CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT NO. 71

A VALUABLE and regular feature of *The Petroleum Engineer*, begun six years ago, the Continuous Tables were designed to save time and effort for the technician and the practical field or plant worker. The tables have proved one of the most popular and helpful departments of *The Petroleum Engineer*. Data are presented in the simplest form available with many types of information included that are best presented by curves or nomographs when three or more variables must be considered simultaneously.

The Continuous Tables have developed as a result of suggestions for new tables, direct contributions, and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

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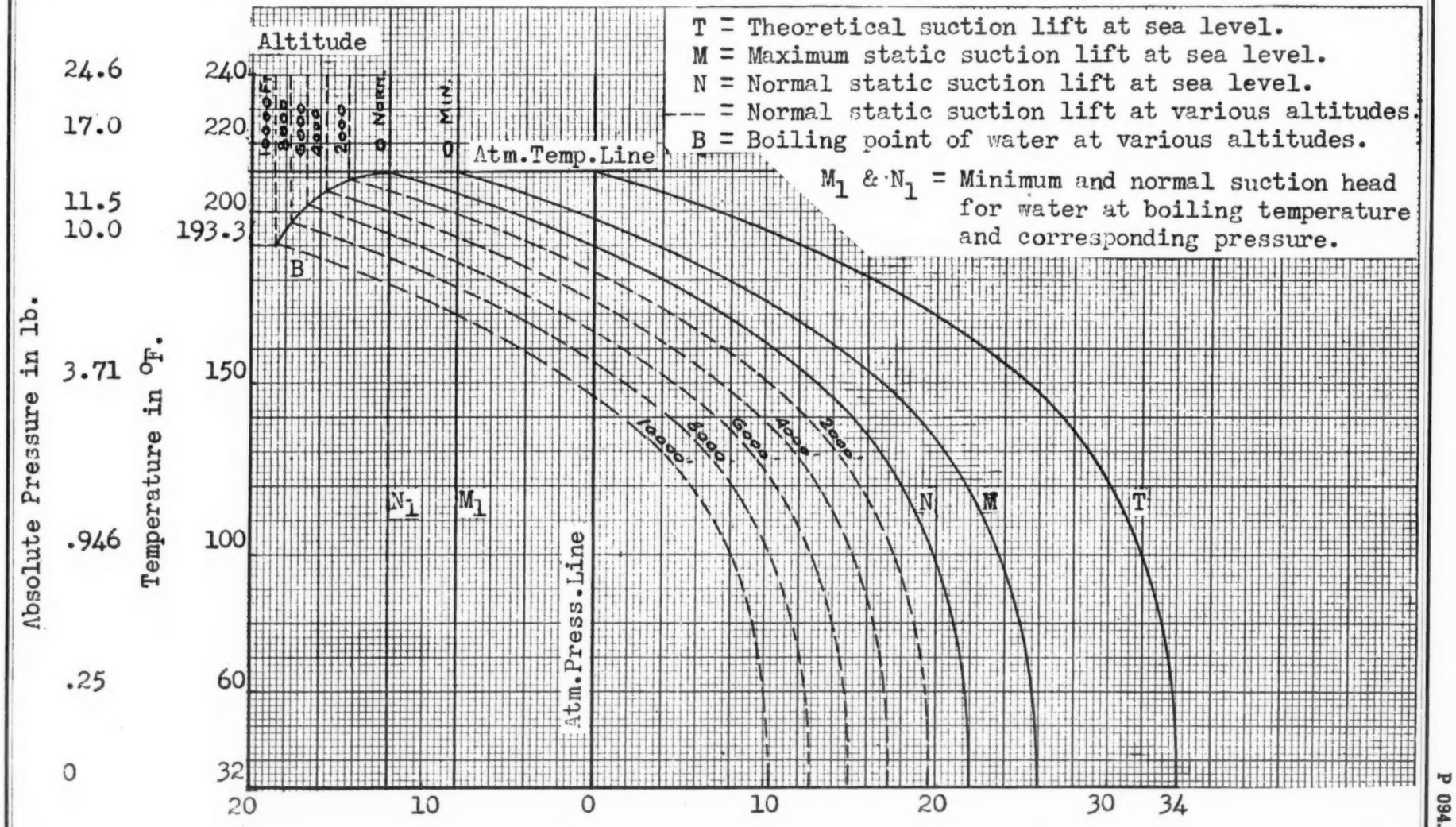
PUMP SUCTION LIFT CHART



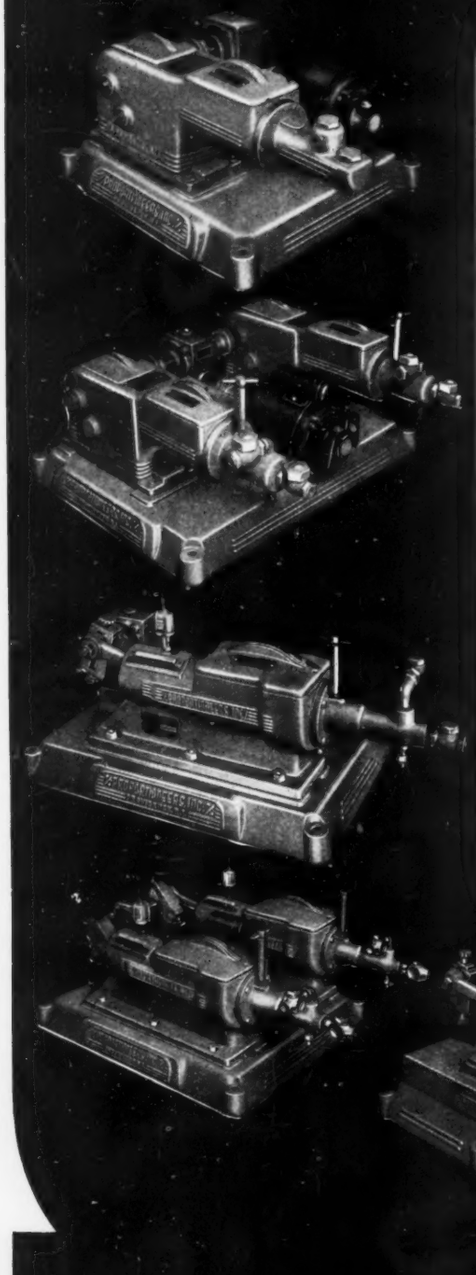
"The suction lift obtainable with a reciprocating pump is affected by the type of pump as well as the design of suction valves, pistons, and suction passages; therefore, the limits shown in the above table are only applicable to so-called 'trade' pumps similar to 6-in. by 4-in. by 6-in. valve plate design duplex pumps."

Reproduced by permission from Standards of Hydraulic Institute.

P 094.86

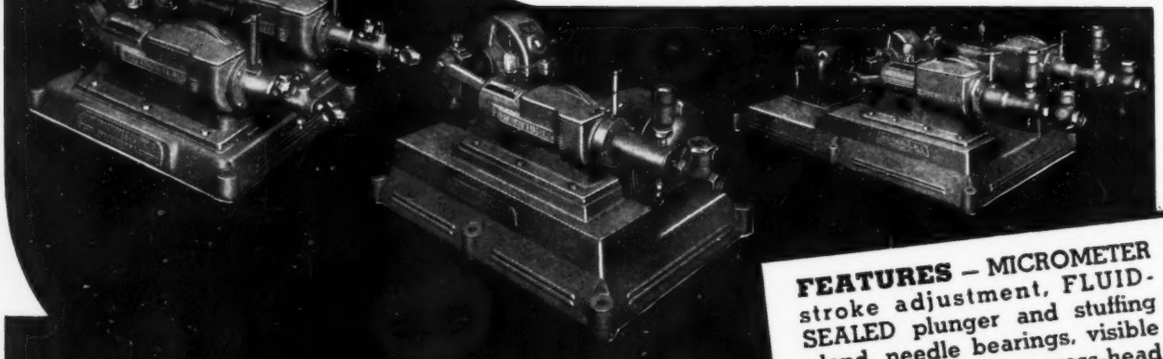
A Complete Line
CHEMICAL PROPORTIONING PUMPS

for the Process Industries



%Proportioneers% Heavy Duty Adjust-O-Feeders with specially designed measuring cylinders, stuffing glands and check valves for all gum inhibitors, sulphuric, nitric and hydrofluoric acids, caustic, solvents, sludge acid, regular and off-grade latex, styrene, butadiene, soap solutions, asphalts, etc.

- **MODEL 1XS *Midget Series Simplex Adjust-O-Feeder***
  Up to 7.5 g.p.h. 1,000 p.s.i.g.
- **MODEL 1XD *Midget Series Duplex Adjust-O-Feeder***
  Up to 15 g.p.h. 1,000 p.s.i.g.
- **MODEL 2XS *Standard Simplex Adjust-O-Feeder***
  Up to 42 g.p.h. 500 p.s.i.g.
- **MODEL 2XD *Standard Duplex Adjust-O-Feeder***
  Up to 84 g.p.h. 500 p.s.i.g.
- **MODEL 2XS *High Pressure Simplex Adjust-O-Feeder***
  Up to 50 g.p.h. 3,000 p.s.i.g.
- **MODEL 3XD *High Pressure Duplex Adjust-O-Feeder***
  Up to 100 g.p.h. 3,000 p.s.i.g.

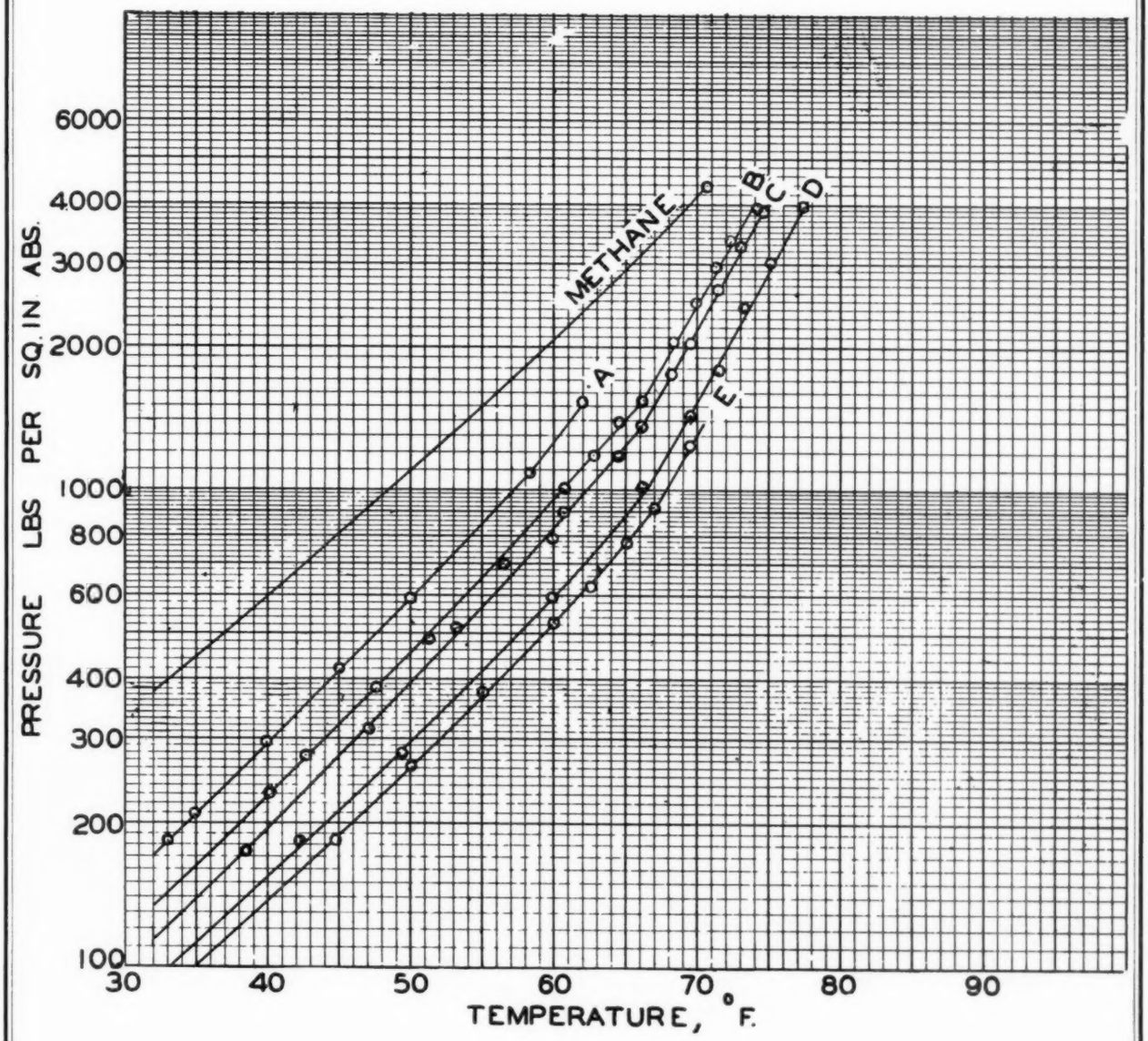


FEATURES – MICROMETER stroke adjustment, FLUID-SEALED plunger and stuffing gland, needle bearings, visible capacity scales, long cross-head guides, interchangeable disc or built-in ball check valves. Each pump tested under job conditions. Certified calibration curves with each unit.

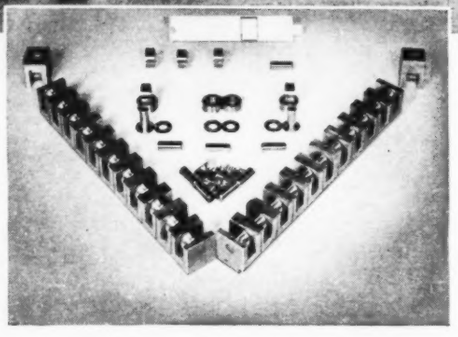
% PROPORTIONEERS, INC. %
28 CODDING ST., PROVIDENCE, R. I.

HYDRATE FORMING CONDITIONS FOR NATURAL GASES

—Chart by George Granger Brown, University of Michigan.

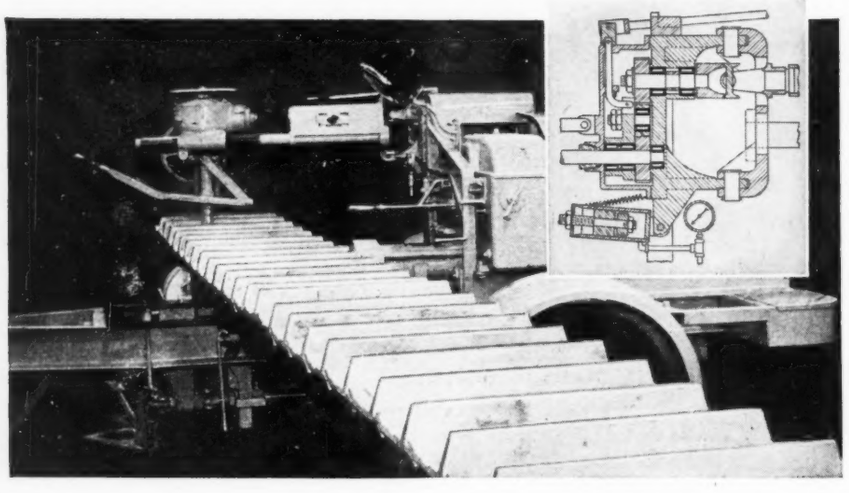


SIMPLER, MORE EFFICIENT PRODUCT DESIGN AND ASSEMBLY is often achieved by the use of special types of bearings such as these Bantam Journal Roller Bearings built for use in the crown and traveling blocks manufactured by Emsco Derrick & Equipment Co. Measuring 27½" O.D. they are provided with thrust shoulders built into outer races to eliminate hazardous thrust washers and contribute to compact design. Bantam's engineering and manufacturing facilities are geared for the prompt delivery of such special bearings for essential purposes.



"SEWING" SHEETS OF STEEL together rapidly with dependable welds to speed shipbuilding is the work of The Linde Air Products Company's "Unionmelt" welding machine. Special anti-friction bearings built by Bantam are used on the pressure and straightening rollers which feed the welding rod. These bearings, shown unassembled in the inset above, assure long, trouble-free service and are typical of Bantam's ability to provide bearings for special applications of all types.

LOW STATIC FRICTION of a Bantam Quill Bearing aids in actuating a safety-stop device on the cam-feed mechanism in this U. S. Tool Company "Multi-Miller," by allowing a normally stationary high-friction bearing on the camshaft and inside the Quill Bearing to turn when pressure on the shaft approaches the overload point.



EXPERIENCED SKILL TO SERVE YOU in the unbiased selection of standard bearings or in the design of bearings for unusual applications is offered by Bantam's engineers. Bantam makes every type of anti-friction bearing—straight roller, tapered roller, needle, and ball. No matter how difficult your bearing problem, TURN TO BANTAM.

UNLOOSENING ROCK-BATTERED BOLTS on the caterpillar tracks of tanks and tractors is the tough maintenance job performed by this track wrench, a product of Rodgers Hydraulic Incorporated. Despite the unusually heavy stresses encountered, dependable power transmission is assured by the high load capacity of eight Bantam Quill Bearings and four Bantam Needle Roller Bearings used in the gear mechanism. In addition, these bearings contribute to compact design because of their small size, as can be seen from the accompanying cross-section drawing, and to low power consumption because of efficient lubrication and low friction coefficient.

ARMY NAVY
BANTAM BEARINGS
STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL
THE TORRINGTON COMPANY · BANTAM BEARINGS DIVISION
SOUTH BEND, INDIANA

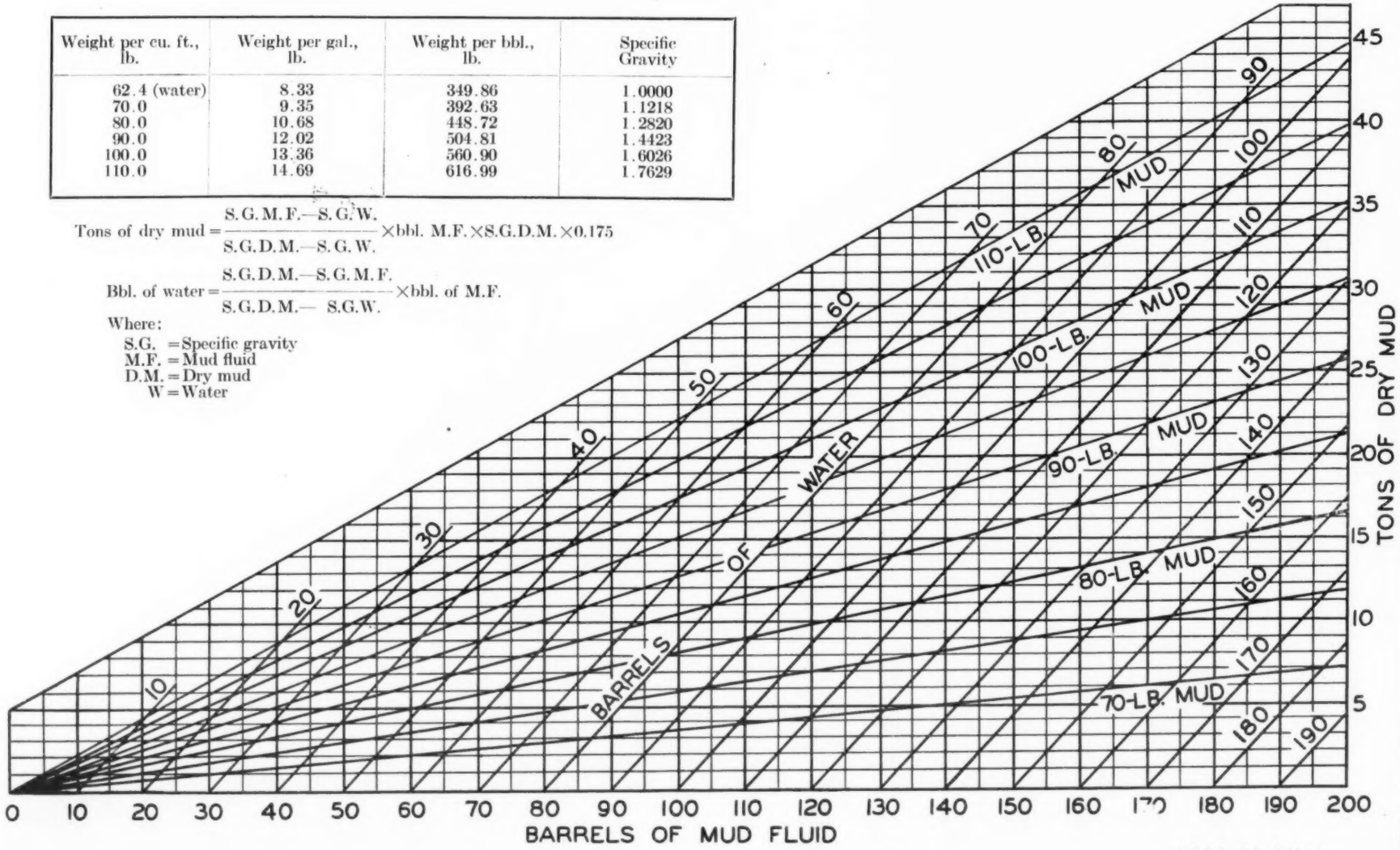
DRILLING MUD CHART FOR 2.5 SPECIFIC GRAVITY CLAY

Weight per cu. ft., lb.	Weight per gal., lb.	Weight per bbl., lb.	Specific Gravity
62.4 (water)	8.33	349.86	1.0000
70.0	9.35	392.63	1.1218
80.0	10.68	448.72	1.2820
90.0	12.02	504.81	1.4423
100.0	13.36	560.90	1.6026
110.0	14.69	616.99	1.7629

$$\text{Tons of dry mud} = \frac{\text{S.G.M.F.} - \text{S.G.W.}}{\text{S.G.D.M.} - \text{S.G.W.}} \times \text{bbl. M.F.} \times \text{S.G.D.M.} \times 0.175$$

$$\text{Bbl. of water} = \frac{\text{S.G.D.M.} - \text{S.G.M.F.}}{\text{S.G.D.M.} - \text{S.G.W.}} \times \text{bbl. of M.F.}$$

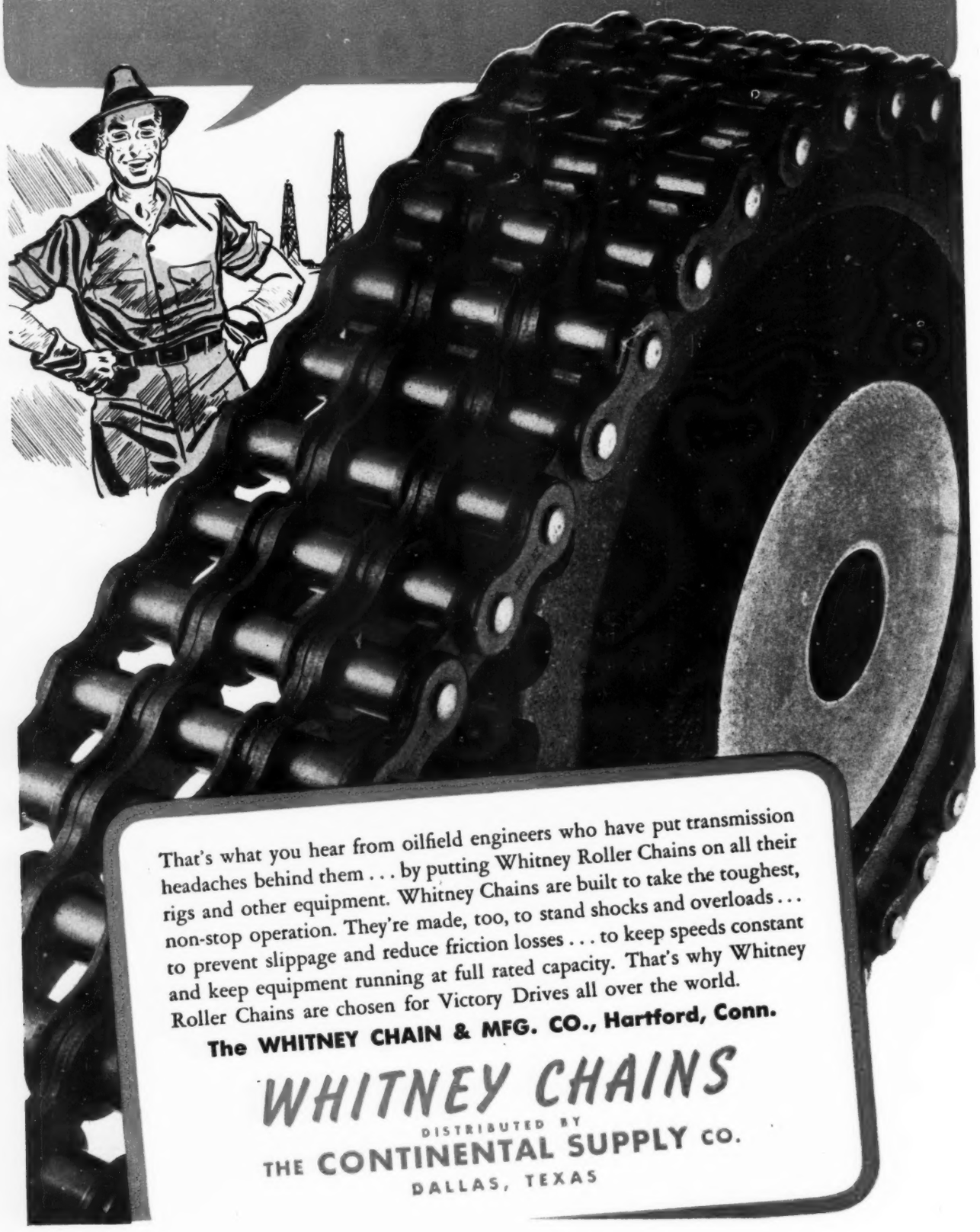
Where:
S.G. = Specific gravity
M.F. = Mud fluid
D.M. = Dry mud
W = Water



U.S.G.S., Taft, California

P 425.218.42

I've Got Plenty of Headaches Nowadays
...BUT POWER TRANSMISSION ISN'T ONE OF THEM



That's what you hear from oilfield engineers who have put transmission headaches behind them . . . by putting Whitney Roller Chains on all their rigs and other equipment. Whitney Chains are built to take the toughest, non-stop operation. They're made, too, to stand shocks and overloads . . . to prevent slippage and reduce friction losses . . . to keep speeds constant and keep equipment running at full rated capacity. That's why Whitney Roller Chains are chosen for Victory Drives all over the world.

The WHITNEY CHAIN & MFG. CO., Hartford, Conn.

WHITNEY CHAINS

DISTRIBUTED BY

THE CONTINENTAL SUPPLY CO.

DALLAS, TEXAS

COMPARISON OF SQUARE FEET OF EXTERNAL SURFACE PROVIDED BY BARE PIPE TUBING AND LONGITUDINALLY FINNED PIPE OR TUBING

This table may be filed under P 734.200.

Pipe or tube size, in.	Surface area of bare pipe or tubing (sq. ft., per ft. of lineal length)	Surface area of longitudinally finned pipe or tubing (sq. ft. per foot of lineal length)						
		Number of fins	Height of longitudinal fin, in.					
			½	⅝	¾	1	1¼	1½
1	0.262	12	1.262	1.512	1.762	2.262	2.762	3.262
		16	1.595	1.929	2.262	2.929	3.595	4.262
		20	1.927	2.345	2.762	2.595	4.429	5.262
1.05 (¾ IPS)	0.275	12	1.275	1.525	1.775	2.275	2.775	3.275
		16	1.608	1.942	2.275	2.942	3.608	4.275
		20	1.942	2.358	2.775	3.608	4.442	5.275
1.25	0.327	16	1.660	1.994	2.327	2.994	3.660	4.327
		20	1.994	2.410	2.827	3.660	4.494	5.327
		24	2.327	2.827	3.327	4.327	5.327	6.327
1.315 (1 IPS)	0.344	16	1.677	2.011	2.344	3.011	3.677	3.344
		20	2.011	2.427	2.844	3.677	4.511	5.344
		24	2.344	2.844	3.344	4.344	5.344	6.344
1.5 O.D.	0.393	16	1.726	2.060	2.393	3.060	3.726	4.393
		20	2.059	2.476	2.893	3.726	4.560	5.393
		24	2.393	2.893	3.393	4.393	5.393	6.393
		28	2.726	3.310	3.893	5.060	6.226	7.393
1.66 (1¼ IPS)	0.434	16	1.768	2.101	2.434	3.101	3.767	4.434
		20	2.101	2.517	2.934	3.767	4.601	3.434
		24	2.435	2.934	3.434	4.434	5.434	6.434
		28	2.768	3.351	3.934	5.101	6.268	7.434
1.9 (1½ IPS)	0.497	20	2.164	2.580	2.997	3.830	4.664	5.497
		24	2.497	2.997	3.497	4.497	5.497	6.497
		28	2.830	3.414	3.997	5.164	6.330	7.497
		32	3.164	3.830	4.497	5.830	7.164	8.497
		36	3.498	4.247	4.997	6.497	7.997	9.497
2 O.D.	0.524	20	2.191	2.607	3.024	3.857	4.691	5.524
		24	2.524	3.024	3.524	4.524	5.524	6.524
		28	2.857	3.441	4.024	5.191	6.357	7.524
		32	3.191	3.857	4.524	5.857	7.191	8.524
		36	3.524	4.274	5.024	6.524	8.024	9.524
2.375 (2 IPS)	0.622	20	2.289	2.705	3.122	3.955	4.789	5.622
		24	2.622	3.122	3.622	4.622	5.622	6.622
		28	2.955	3.538	4.122	5.289	6.455	7.622
		32	3.289	3.955	4.622	5.955	7.289	8.622
		36	3.622	4.372	5.122	6.622	8.122	9.622
2.5	0.654	20	2.321	2.737	3.154	3.987	4.821	5.654
		24	2.654	3.154	3.654	4.654	5.654	6.654
		28	2.987	3.571	4.155	5.321	6.482	7.654
		32	3.321	3.987	4.654	5.987	7.321	8.654
		36	3.654	4.404	5.154	6.654	8.154	9.654
		40	3.987	4.821	5.654	7.321	8.988	10.654
2.875 (2½ IPS)	0.753	20	2.420	2.836	3.253	4.068	4.920	5.753
		24	2.753	3.253	3.753	4.753	5.753	6.753
		28	3.086	3.670	4.253	5.420	6.586	7.753
		32	3.420	4.086	4.753	6.086	7.420	8.753
		36	3.753	4.503	5.253	6.753	8.253	9.753
		40	4.086	4.920	5.753	7.420	9.086	10.753
3 O.D.	0.785	20	2.452	2.868	3.285	4.118	4.952	5.785
		24	2.785	3.285	3.785	4.785	5.785	6.785
		28	3.118	3.702	4.285	5.452	6.618	7.785
		32	3.452	4.118	4.785	6.119	7.452	8.785
		36	3.785	4.535	5.285	6.785	8.285	9.785
		40	4.118	4.952	5.785	7.452	9.118	10.785
		44	4.452	5.368	6.285	8.118	9.952	11.785

Data courtesy of The Brown Fintube Company.

EVERY ENGINEER SHOULD KNOW ABOUT

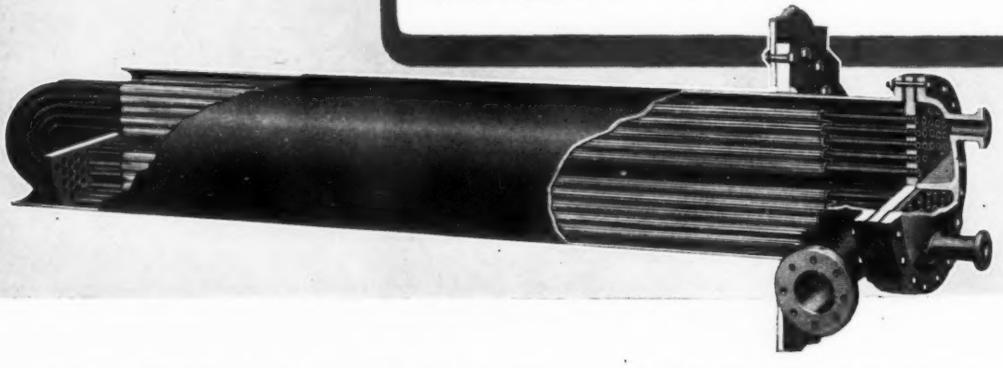
BROWN FINTUBE HEAT EXCHANGERS

15" x 22'0" OVERALL, TYPE BFT-2 TANK SUCTION HEATER PROVIDES 1560 SQ. FT. OF EFFECTIVE SURFACE... TRANSFERS 3,060,000 BTU PER HOUR

TYPE BFT-2 OIL TANK SUCTION HEATER

PERFORMANCE DATA

	COLD MEDIUM	HOT MEDIUM
In (Shell or Tubes)	Shell	Fintubes
Medium	Bunker "C" Fuel Oil	15# Ga. Saturated Steam
Gravity °API	10	—
Quantity GPH 60° F.	9,500	—
Inlet Temp. °F.	60	250° F.
Outlet Temp. °F.	150	250° F.
Heat Duty BTU/Hour	3,060,000	—
Pressure Drop #/ sq. in.	5	—



If you want greatest known efficiency—and capacity—in transferring heat between two commodities having uneven heat transfer co-efficients, —it will pay you to thoroughly investigate Brown resistance-welded integrally-bonded Fintubes and Brown Fintube Heat Exchangers.

Through the use of Brown Fintubes having the desired number and depth of fins, the primary and secondary tube surfaces of Brown Fintube Heat Exchangers can be proportioned to the transfer co-efficients of the materials being heated or cooled. This avoids the necessity of using hundreds, sometimes thousands of feet of bare tubing to satisfy the requirement of the commodity having lower heat transfer co-efficient. It permits a fewer number, or shorter, Brown Fintubes to be used for a given heat transfer service than if plain bare tubes were used . . . and results in small shells, less weight, less pressure drop, and many other important savings in manufacturing, shipping, installation and maintenance costs.

Brown Integrally Bonded Fintubes are used in all Brown Fintube Heat Exchangers—in exchangers made by most other manufacturers—and are available in a wide variety of sizes, and in mild carbon or special steels, for practically any heating or cooling requirement.

Six standard and many special types of Brown Fintube Heat Exchangers meet every requirement for effecting transfers between liquids and gases, and other commodities having unequal transfer co-efficients, —and provide the high thermal efficiency and trouble-free operation that only Brown resistance-welded integrally-bonded Fintubes can give you. More complete details and descriptive literature furnished gladly. Let us quote on your heat exchanger requirements.

THE BROWN FINTUBE CO.

125 FILBERT STREET • ELYRIA, OHIO

MANUFACTURERS OF INTEGRALLY BONDED FINTUBES AND FINTUBE HEAT EXCHANGERS

SPEEDS AND AMOUNT OF ELECTRODE, FOR WELDING STANDARD PIPE, BUTT JOINTS

This table may be filed under P 622.320.

Size of Pipe		Current, amps.	Minimum arc volts	Arc time, minutes per joint	Number of passes	Electrode size, in.	Pounds of electrode per joint
Diameter, in.	Thickness, in.						
2 (see Fig. 1)	0.154	120 140	25	5.5	1 2	5/32	0.35
3 (see Fig. 1)	0.216	120 140	25	7.0	1 2	5/32	0.44
4 (see Fig. 2)	0.237	120 160	25	9.0	1 2 3	5/32 3/16 3/16	0.64
5 (see Fig. 2)	0.258	120 160	25	11.3	1 2 3	5/32 3/16 3/16	0.81
6 (see Fig. 2)	0.280	120 160	25	13.5	1 2 3	5/32 3/16 3/16	0.96
8 (see Fig. 2)	0.322	150 170	25	17.8	1 2 3	3/16	1.33
10 (see Fig. 3)	0.365	150 170	25	22.0	1 2 3 4	3/16	1.65
12 (see Fig. 3)	0.375	150 170	25	26.5	1 2 3 4	3/16	2.0
14 (see Fig. 3)	0.375	150 170	25	31.3	1 2 3 4	3/16	2.3

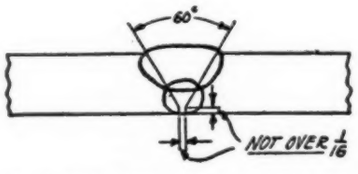


Fig. 1. Type of butt weld for 2- and 3-in. pipe

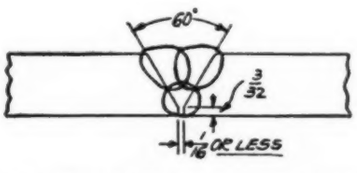


Fig. 2. Type of butt weld for pipe 4, 5, 6, and 8 in. in diameter

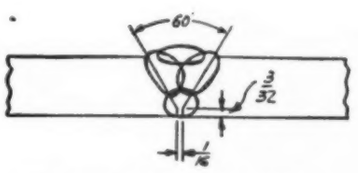
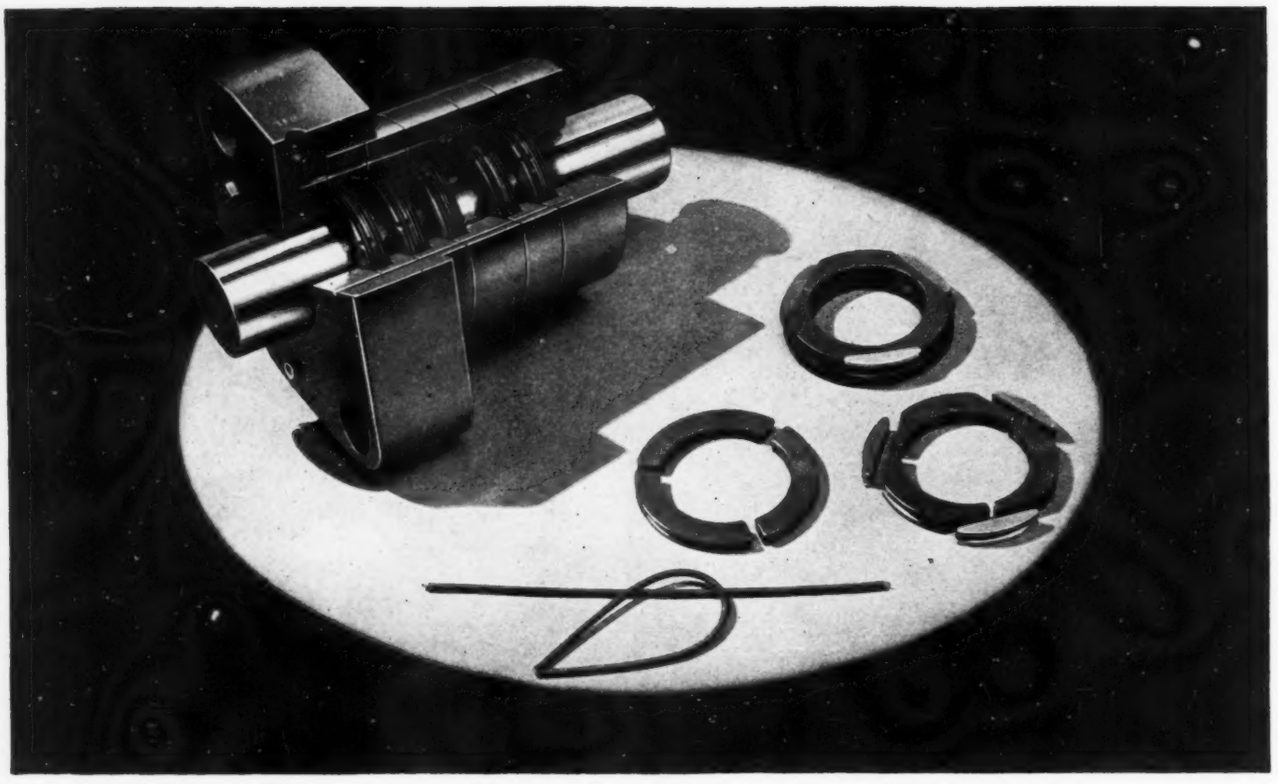


Fig. 3. Butt weld for pipes with diameters of 10, 12, and 14 in.

Data courtesy The Lincoln Electric Company, Cleveland, Ohio.



PRECISION
COMPRESSOR ROD PACKINGS

MORE HORSEPOWER AT LESS COST is the net result when your engine or compressor is equipped with COOK'S Precision Metallic Packings. Here's why:

Precision construction assures positive seal of the pressure.

Basic design allows for rod misalignment and vibration, without added friction and wear, provides automatic compensation for wear and guarantees a constant oil film between rings and rod.

Regardless of the make or type of your equipment you can have the improved operation and years of repair-free service COOK'S Precision Packings bring, because there is a proved type and material for all prevailing pressures and temperatures. Shown above is the annular cup type.

Many engine and compressor manufacturers supply COOK'S Packings as original equipment—others furnish them on request. So, when ordering new equipment, specify COOK'S Packings.

For equipment in service, write or call our nearest office.

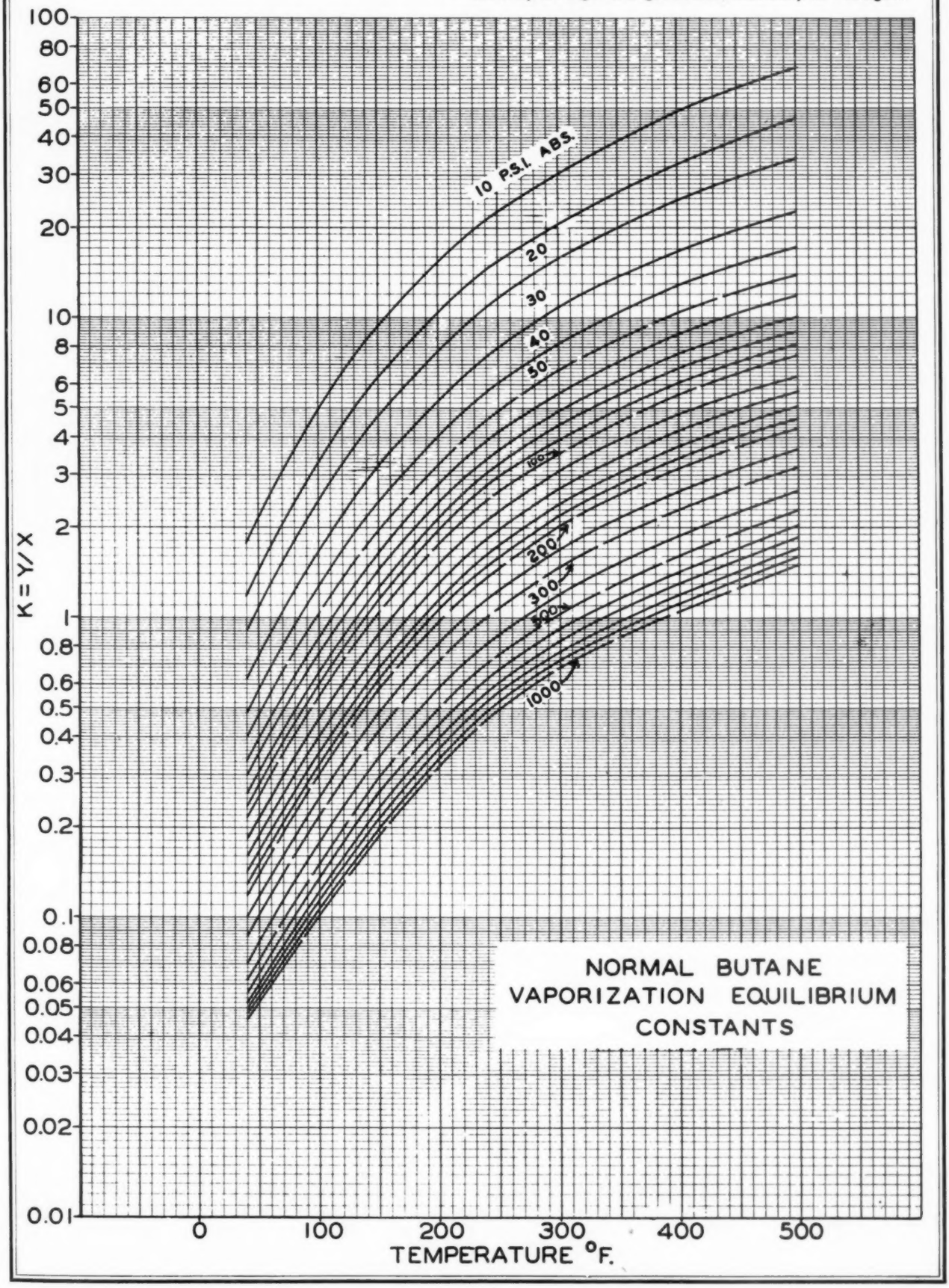
C. LEE COOK MANUFACTURING CO., Incorporated, Louisville, Kentucky. Branch Offices and Representatives — Baltimore, Boston, Chicago, Cleveland, Houston, Los Angeles, Mobile, Montreal, New Orleans, New York, Portland, Oregon, San Francisco, Seattle, Tulsa.

"Sealing Pressures Since 1888"

COOK'S METALLIC PACKINGS

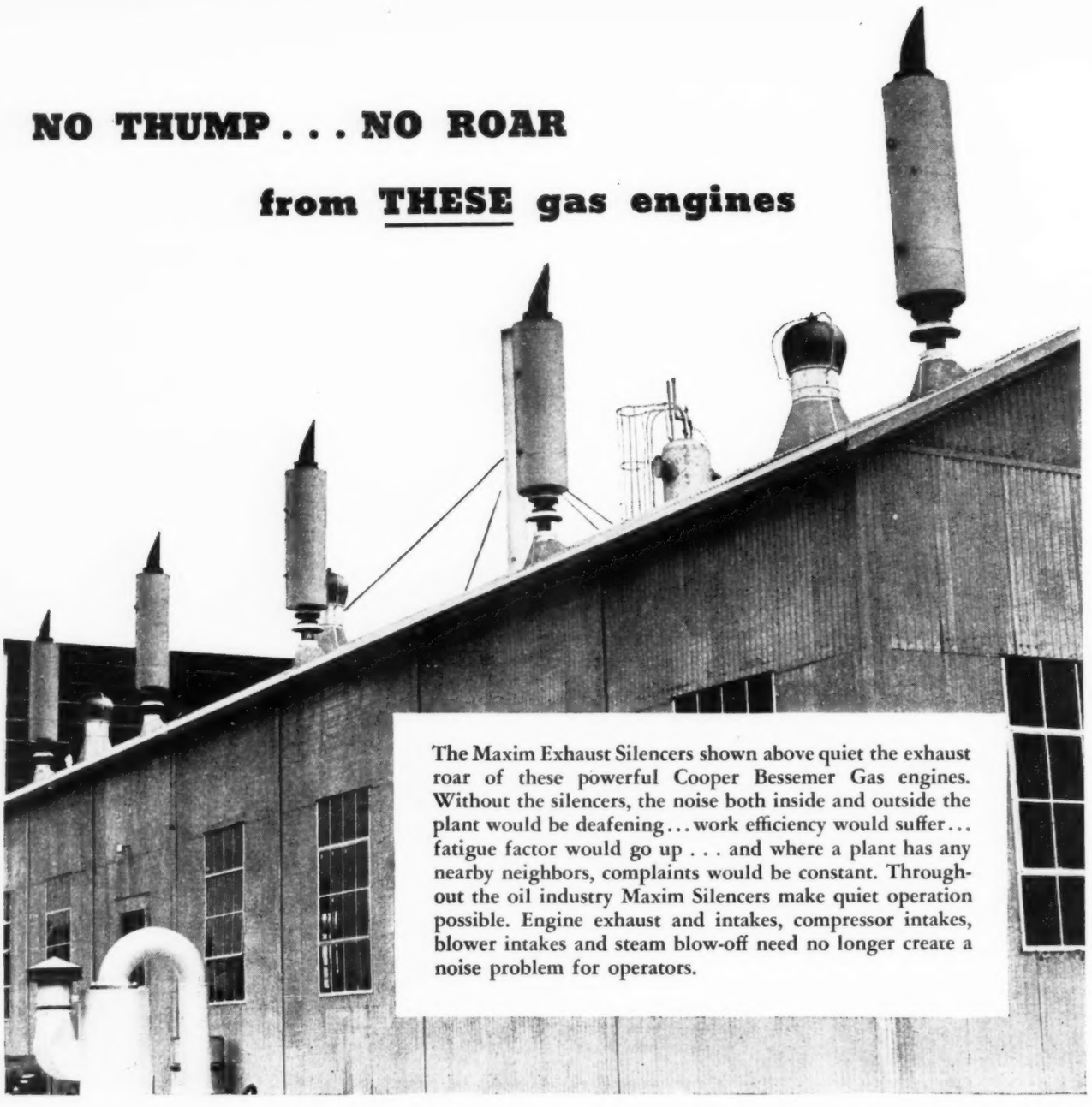
VAPORIZATION EQUILIBRIUM CONSTANTS FOR NORMAL BUTANE

—*Chart by George Granger Brown, University of Michigan.*



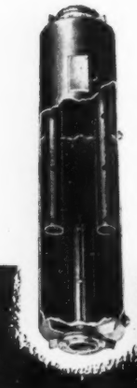
NO THUMP . . . NO ROAR

from THESE gas engines



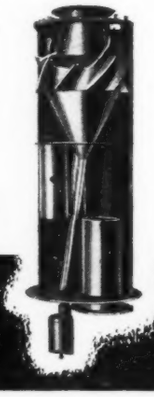
The Maxim Exhaust Silencers shown above quiet the exhaust roar of these powerful Cooper Bessemer Gas engines. Without the silencers, the noise both inside and outside the plant would be deafening... work efficiency would suffer... fatigue factor would go up . . . and where a plant has any nearby neighbors, complaints would be constant. Throughout the oil industry Maxim Silencers make quiet operation possible. Engine exhaust and intakes, compressor intakes, blower intakes and steam blow-off need no longer create a noise problem for operators.

MAXIM WASTE HEAT UNITS combine silencing with the conservation of waste exhaust heat to produce steam or hot water. Bulletins WH-100 and WH-103 on request. The Maxim Silencer Co., 90 Homestead Ave., Hartford, Conn.



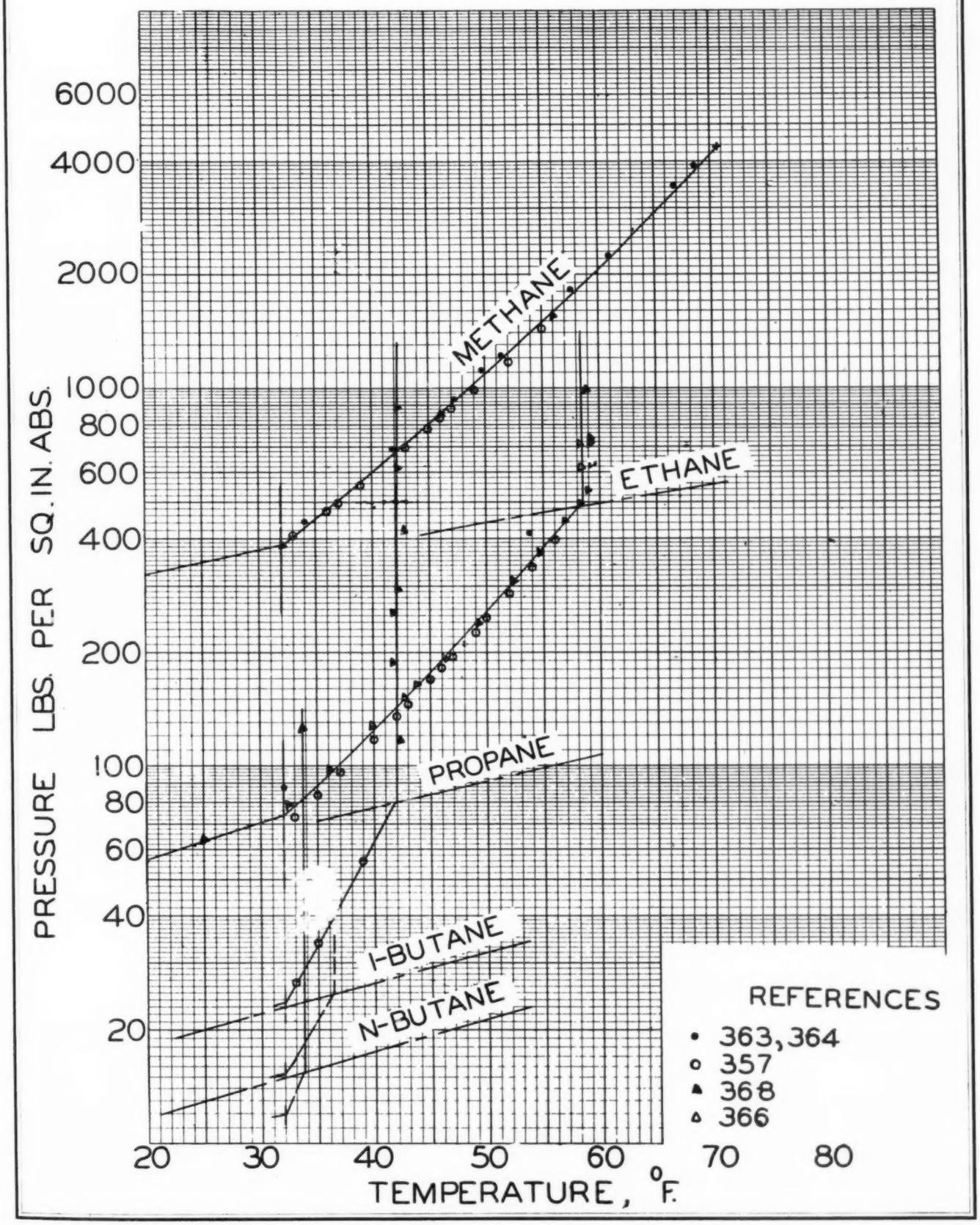
MAXIM

SILENCERS and SPARK ARRESTORS



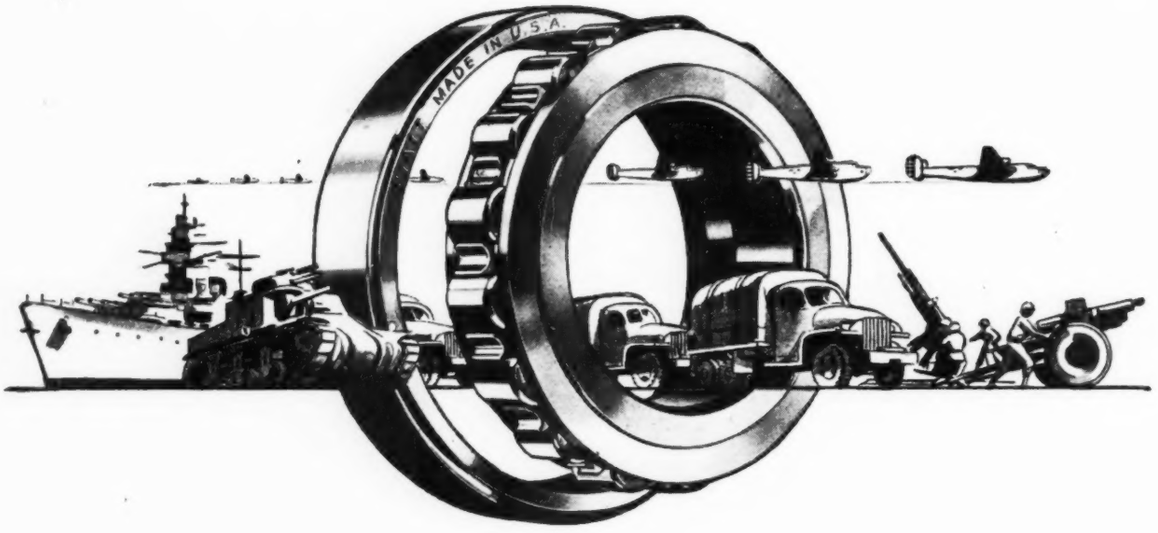
HYDRATE FORMING CONDITIONS FOR PARAFFIN HYDROCARBONS

—Chart by George Granger Brown, University of Michigan.



Keeping Them Rolling—

Our Job Yesterday, TODAY and Tomorrow!



TODAY the heavily loaded shafts, gears and wheels of vital war equipment turning on Hyatt Roller Bearings, are well protected against shocks, excessive wear and breakdowns.

And other smooth rolling Hyatts, of the same microscopic accuracy and unyielding stamina, are serving round-the-clock in the machines which help build mighty guns and planes and tanks and ships.

Prolonging machine life... keeping equipment going... has been a job done well by Hyatts for the past fifty years. And after this war's won, there will be many more industrial, agricultural and transportation bearing applications in which Hyatts will continue to serve and save for another half century.

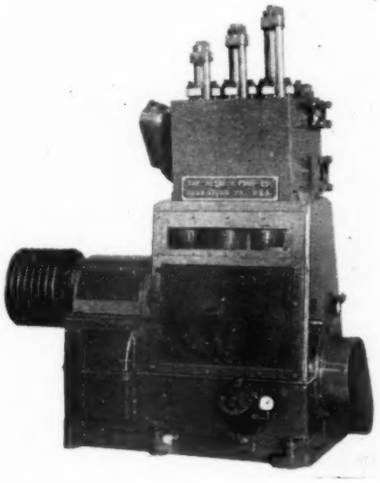
Is there any way we can help you now? Hyatt Bearings Division, General Motors Corporation, Harrrison, N. J.

HYATT ROLLER BEARINGS

MACHINERY and EQUIPMENT

New Pump Drive Arrangement

A NEW drive arrangement for Aldrich inverted vertical Triplex pumps has been announced by the Aldrich Pump Company, Allentown, Pennsylvania. This design provides for



built-in pump gearing with extended pinionshaft, allowing for direct connection through flexible coupling to motor, or for V-belt drive to prime mover as shown in accompanying photograph.

The pump can now be supplied with any of three drive arrangements, viz.: direct to gear-head motor, through chain, flat or V-belt drive from extended crankshaft to prime mover, and through built-in pump gearing. It finds many applications in pipe-line service, water flooding, central hydraulic pumping systems, or similar services requiring high-pressure pumping.

Republic Pneumatic Transmitter

THE Republic Flow Meters Company, 2240 Diversey Parkway, Chicago, Illinois, announces a new Pneumatic Differential Pressure Transmitter for measuring flow and level. The device is expected to find a wide market in chemical plans, oil refineries, and other process industries where fire and explosion hazards are present because it avoids the necessity of running long lines containing poisonous or explosive products.

The company has been giving this transmitter very exacting field tests for the last two years and reports unusually important and valuable operating features that various applications have brought to light. The pneumatic device converts a differential pressure, such as is produced by the flow of a fluid through an orifice or by liquid level in a vessel, into an air pressure that varies proportionally with the differential pressure.

Ranges are available from 0.9 in. to 25 in. of water differential for working pressures up to 15 lb. per sq. in.; 7 in. to 50 in. of water for working pressures up to 25 lb. per sq. in., and 13 in. to 800 in. of water for working pressures up to 600 lb. per sq. in. Ranges are very easily changed in the field with a minimum substitution of parts. The company can provide special heads for pressures up to 2000 lb. per sq. in.

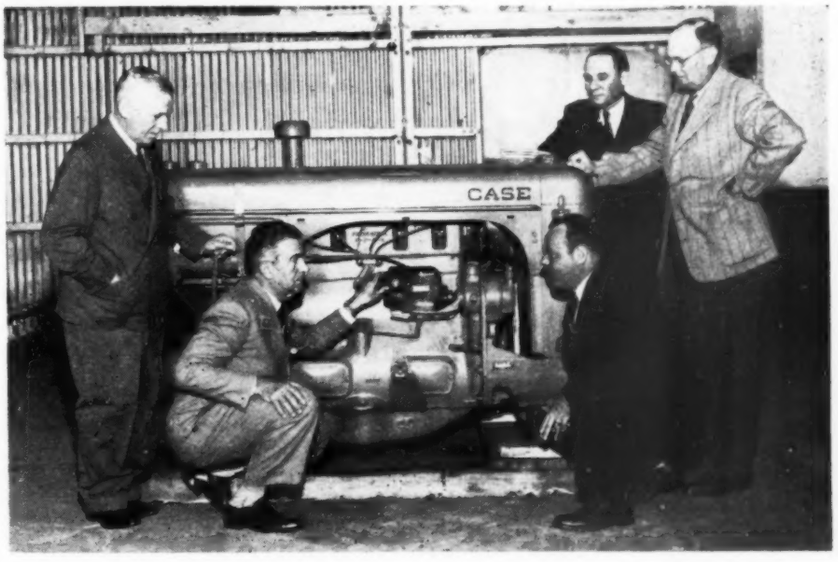
The company guarantees transmitting pressure vs. measured differential within ½ percent of meter range. The device has shown unusual sensitivity and responsiveness. When a receiving instrument was installed adjacent to the transmitter, flow changes were shown almost instantly. With 500 ft. of ¼ in. O.D. tubing, the full value of the change registered on a Republic receiver in 15 sec.

The company reports that the effect of ambient temperature variations on the accuracy of this new Republic transmitter is negligible. Tests have also shown that normal frequencies of vibration present in industrial and processing plants do not affect the device.

Although a new member of the highly regarded Republic Flow Meters Family, the Pneumatic Transmitter has already created considerable interest among engineers who have observed its operation, the manufacturer asserts.

Case Oil-Field Engines

BEN DUMM, chief engineer of the Allied Supply Company, Gas Engine and Pump Department, explains many of the features of the Case oilfield engine to Bob Jones, manager of the Order and Service Department, while company executives listen in. Standing left to right are Gilbert Nesheim, Gordon B. Tunnell, and J. E. Aderhold, Jr. Kneeling are Ben Dumm and Bob Jones. Allied Supply Company has recently been appointed exclusive California distributors for J. I. Case oilfield engines.



Electronic Meter

A NEW electronic time-interval meter for accurately measuring extremely short intervals — as low as 100 microseconds — has been announced by the Special Products Section of the General Electric Company, Schenectady, New York. Specifically, the meter is designed for measuring the time interval between two events that can be converted into electrical impulses, such as the elapsed time between the closing of two controls; between two impulses to a phototube, and between an electrical impulse and a light impulse.

Consisting of two units — an electronic panel and a phototube with its preamplifier stage — the meter has eight ranges, selected by means of a tap switch so that any time interval of a length between 0.0001 sec. and 3 sec. can be measured. A standard indicating instrument calibrated in milliseconds gives a direct reading of the time interval measured.

Operating from a 115-volt, 60-cycle lighting circuit, the meter is stabilized so that normal line-voltage variations do not affect its accuracy, which is 2 percent of full scale value, or one scale division. The meter will continue to indicate the time interval after measuring, with a drift of less than one division per minute. When another reading is required, a push button immediately clears the dial.

McKissick Snatch Block

THE latest McKissick block to come off the production line is a snatch block, the principal feature of which is that it may be threaded while in suspension.

According to the manufacturer, McKissick Products Corporation, Tulsa, Oklahoma, this block is particularly advantageous for use in heavy trucking where a gin pole or crane is also in use. It is not necessary to take the block down when re-threading is necessary, for by simply removing the locking pin one of the side plates slides open and the line may then be inserted and properly threaded.

The hook is heat-treated forged-steel, which is flatted for greater strength. It swings free on the cross member and also swivels, thereby aligning itself to direction of the pull without undue strain or bind. The unusually large center pin is shouldered and locked to the plates to insure free movement of the sheave under heavy loads.

Another feature of these blocks is the interchangeability of bearings, sheave pins, connections, and sheaves, with respect to line grooving.

Asbestos Cement Conduit

A NEW asbestos cement conduit, intended principally for cable installation, is announced by The Philip Carey Manufacturing Company, Lockland, Cincinnati, Ohio. An outstanding feature of the conduit is the exclusive "Flexcaulk" coupling, made expressly for and supplied together with the conduit.

"Flexcaulk" coupling consists of a tubular housing of tough, rigid, blow-resisting asbestos-cement, to which is bonded a liner of time-resisting mineralized asphalt compound, formed into a barrier-type, tapered liner. Because of its special construction, "Flexcaulk" coupling adds a new flexibility without sacrificing any of the desirable characteristics of a conventional type coupling of unusual strength, according to the manufacturer. It permits a flexible, self-aligning, water-tight joint of exceptional quality, when properly assembled with a joint-sealing compound.

Because "Flexcaulk" coupling is employed with non-taper type conduit, the field assembly of short lengths of complete duct runs, or the fabrication of radius sweeps for clearing fixed obstructions, becomes a simple, inexpensive job, it is stated.

The conduit is made in two thicknesses, for installation with or without concrete encasement.

"Gee whiz, I feel like a drill pipe without Patterson-Ballagh Protectors"

There are "slim pickin's" in an exposed drill pipe after it has battled away in three or four wells *without* Patterson-Ballagh Protectors. The tool joints are pretty well shot. The pipe is battle-scarred with abrasion. But with Patterson-Ballagh Protectors, drill pipe will serve in well after well, giving greatly increased life. The cushioning action of the Protectors saves wear-and-tear on tool joints. Friction is reduced. Fatigue is retarded.

"Best bet yet"

See Composite Catalog

PATTERSON-BALLAGH Corporation

Los Angeles Houston

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Houston Nomads Hold Monthly Meeting

Warren L. Baker, editor of *The Oil Weekly*, was the principal speaker at the April meeting of the Houston Chapter of Nomads. Baker spoke on the domestic oil situation, the problems confronting oil men today, and the general outlook for the oil industry for the year 1943.

Several foreign guests were in attendance, including T. J. Walne, Neil and Massey Company, Ltd., Port-of-Spain, Trinidad, and Walter Wells, Consolidated Oils, Ltd., Venezuela.

Other guests included J. C. Ballagh, Patterson-Ballagh Corporation, California; Wm. Alliger, manufacturers' representative, Houston, and R. Hoesbein, M. H. Detrick Company, Chicago.

Walter Miller Honored

Walter M. Miller, vice-president in charge of manufacturing for Continental Oil Company, Ponca City, Oklahoma, on May 4 was awarded an honorary doctor of engineering degree by the University of Tulsa. The award was granted in recognition of more than 30 years' service in the petroleum industry. Known particularly for his work in the development of modern lubricating oils, Dr. Miller was the first in America to recognize the value and promote the use of synthetic additives.

WALTER MILLER

S. Robishaw Passes Away

S. Robishaw, manufacturer of oil tools and equipment, died on April 21.

Robishaw was born on December 22, 1885, and spent most of his life in the oil business. Together with his partner of many years, George J. Barrett, he invented many successful oil tools, among the best known of which is the Barrett-Robishaw Retractable Core Barrel and the Barrett-Robishaw Casing Mill. His more recent business interests were the Barrett and Robishaw Casing Mill Company and the Universal Core Barrel Company, Houston, Texas. At the time of his death he was a partner with Barrett in both of these companies.

He is survived by his widow, one daughter, Miss Louise Robishaw, and two sons, Captain A. P. Robishaw, with the U. S. Army Engineers, and Earl J. Robishaw.

Retired Oil Executive Passes On

L. J. F. Morison, who, for 20 years, was an officer of Petroleum Rectifying Company of California, died in Los Angeles on April 16. He had been affiliated with the oil industry since 1910 except for a period during the first World War when he served in a government position with the Grain Administration. In 1920 he joined Petreco as assistant secretary and was elected secretary the following year. At his retirement in 1940 because of poor health, Morison was secretary-treasurer and a director of Petrolite Corporation, Ltd.

McCarty Company Vice-President Elected

Announcement has been made of the election of Hiram E. Cassidy, vice-president of The McCarty Company, to the chairmanship of the Southern California Chapter of the American Association of Advertising Agencies. This honor follows his recent election to the Board of Governors.

THERE WILL BE A TOMORROW

but let us plan for it today!

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Jones and Laughlin Steel Corporation

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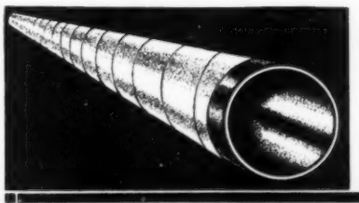
HILL-HUBBELL has already laid its plans for post-war activity. Then when gas, oil and waterworks engineers design permanent pipe lines, HILL-HUBBELL factory processed Steel Pipe Protection will be available—and better than ever.



HILL-HUBBELL Steel Pipe Protection is a scrupulous mechanical application job. Our name on the imprinted kraft wrapping is your assurance of honest workmanship.

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Midwest Piping and Supply Given Award

Presentation of the Army and Navy "E" to the employees of Midwest Piping and Supply Company's St. Louis works was made last month. Men and women associated with the company as well as many friends attended the ceremony of presentation.

J. W. Vaiden New President N.G.A.A.

James W. Vaiden, vice-president of Skelly Oil Company, Tulsa, Oklahoma, was elected president of the National Gasoline Association of America at the annual meeting in Dallas, Texas. Vice-presidents are: Henry H. Beeson, Sabine Valley Gasoline Company, Shreveport; H. A. Ells, Cities Service Oil Company, Bartlesville, Oklahoma; R. A. Carter, Continental Oil Company, Ponca City, Oklahoma, and C. R. Williams, The Chicago Corporation, Corpus Christi, Texas.

W. F. Lowe, secretary-manager, was renamed by the new board.

Directors elected to serve for a two-year term are: J. S. Abercrombie Company, The Atlantic Refining Company, Carbide and Carbon Chemicals Corporation, Continental Oil Company, Cities Service Oil Company, Glacier Production Company, Lone Star Producing Company, Owens, Libbey-Owens Gas Department, The Parade Company, Shamrock Oil and Gas Corporation, Shell Oil Company, Inc., Union Oil Company of California, and Virginia Gasoline and Oil Company.

Directors named last year who will service with the above new ones are: The Carter Oil Company, Coltexo Company, Cotton Valley Operators Committee, The Chicago Corporation, Glen Rose Gasoline Company, Hanlon-Buchanan, Inc., Kansas Power and Light Company, Phillips Petroleum Company, Sabine Valley Gasoline Company, Skelly Oil Company, Standard Oil Company of California, United Gas Pipe Line Company, and Warren Petroleum Corporation.

New Consulting Firm

Under the name of McCarthy and O'Brien, Geo. H. McCarthy and Jerome J. O'Brien have recently opened an office in Los Angeles, California, and are specializing as consultants in petroleum exploration and management. Their services include the combination of geological exploration, petroleum engineering, property valuation, and contract management of producing properties.

McCarthy is a graduate of the University of California and entered the oil business in 1920 in the geological

J. J. O'BRIEN

G. H. McCARTHY

department of the Amalgamated Oil Company. Recently he has been general manager of Franco Oils, Ltd., and its subsidiary companies in Canada.

O'Brien was graduated from the Universitiy of California at Los Angeles in geology and from the University of Southern California in petroleum engineering. Since 1940 he has been chief geologist of the Sunset Oil Company, Los Angeles.

In addition to general consulting petroleum engineering and geological work, this firm will act as management contractors and as such perform all the duties of a production department including all the functions of the land, petroleum engineering, geological, and exploration departments. L. C. Lamp, general superintendent for the Sunset Oil Company for the last seven years, will supervise the field activities.

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3 MUSTS FOR FULL ROLLER BEARINGS

Americans are *simple* . . . because simplicity of design assures long life, less trouble-shooting, easier replacement. AMERICANS are *precise* . . . for precision in full roller bearings is essential to smooth, quiet, flawless operation of heavy equipment. AMERICANS are *strong* . . . as the success of every other factor depends upon full strength to meet the demands of the service involved, with an ample margin of safety.

Our engineers will welcome your problems.

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AMERICAN
Heavy-Duty ROLLER BEARINGS

Death Takes John McFadyen

John McFadyn, 72, an employee of The Ohio Oil Company for 47 years, died recently at his home, 619 North Sierra Drive, Beverly Hills, California, from a heart attack.

A native of Canada, McFadyen began his long career in the oil industry there when he was 15 years old. In June, 1894, he came to the United States and settled in Rudolph, Ohio.

On June 15 of that year he was given a job of fighting a fire in a swampy area in Wood County, which was endangering the wooden rigs and tanks belonging to The Ohio Oil Company in that region. When the fire fighting job was completed, he was given permanent employment as a pumper by the late I. C. Nevills who, at that time, was district foreman for The Ohio Oil Company. He remained in the employ of the company until his retirement June 1, 1941.

On May 28, 1925, McFadyen was elected director and vice-president of The Ohio Oil Company. He was also vice-president of the Mountain Fuel Supply Company and president and director of The Rocky Mountain Gas Company.

Soldiers Praise Le Roi Compressors

Praise directly from the soldiers who use them was received for mobile air compressors made by Le Roi Company, Milwaukee, Wisconsin. A cable from North Africa to British Information Services in New York stated that the Le Roi compressors played a vital part in solving the 8th army's military construction problems. Used in intense heat and penetrating sand, the British soldiers praised the compressors as "an excellent piece of craftsmanship." They are used for rock drilling in construction of roads, used to drive a circular saw for timber ripping, and for many other purposes. The soldier in charge of the compressors was quoted as saying that one "had never failed and, what is better still, never jammed."

Peterson Heads Supply Men's Association

Charles D. Peterson, Fisher Governor Company, was chosen president of the Natural Gasoline Supply Men's Association at the annual convention in Dallas, Texas.

A. M. Buxton, Cooper-Bessemer Corporation, and J. A. Knebel, Joseph A. Coy Company, were named vice-presidents. V. C. Canter, Frick-Reid Supply Corporation, is treasurer.

Production Award to Johns-Manville

More than 4000 Johns-Manville workers and members of their families who packed into an improvised auditorium to celebrate formal raising of the Army-Navy "E" flag over their Manville, New Jersey, factory recently, received a remarkable tribute from Major General Thomas E. Robins.

"I am convinced," General Robins said, "that you men and women of the Johns-Manville factory have a wider and more diversified part in the war effort than any other group in the United States!"

The major general, chief of the Construction Division, O.C.E., together with other Army and Navy officers inspected the Johns-Manville plant earlier in the day. The flag ceremony, staged at noon in one of the huge warehouse buildings that had been cleared for the occasion, was followed by a luncheon in which the entire plant personnel, wives, families, and visitors were served.

Named Distributor

Petroleum Equipment Company, Los Angeles, California, will act as Pacific Coast distributor of Bethlehem pumping units for the Bethlehem Supply Company, Tulsa, Oklahoma, a subsidiary of Bethlehem Steel Corporation.

8 Tested methods for conserving brake linings
1. Before drill pipe is run in, be sure water is on water-cooled rims.
2. Reverse bands for 40% greater life. This is possible if live and anchored ends are interchangeable and when anchored end is half-worn.
3. Use segmental form lining to simplify application . . . permit release of worn particles . . . and increase heat dissipation.
4. Before applying lining, stone or smooth rough rims.
5. Never use clay, oil or other foreign materials to control friction. Early lining replacement is often made necessary by gummed brake surfaces.
6. Check adjustment of brakes and clutches often. This will prevent unequal wear, and inefficient, noisy operation.
7. Keep bands in round and unkinked when relining. This assures longer life of lining by preventing localized heating and excessive high pressure areas. Also, reduces drum checking.
8. True up scored or heat-checked rims with whetstone if other equipment is not available.
START RIGS OFF RIGHT by using J-M 420 Rotary Lining. Tough . . . durable . . . assures easy load control, even feed-off and high braking efficiency. Send for brochure FM-10A. For further suggestions on conserving Friction Materials, as well as Packings, Insulations, Roofings and Refractory Cements, ask for the new J-M Manual "101 Suggested Good Operating Practices." Johns-Manville, 22 E. 40th St., New York, N.Y.
JM
JOHNS-MANVILLE 420 Rotary Lining

Speakers Entertain Los Angeles Nomads

Two speakers of note entertained the Los Angeles Chapter of Nomads at the regular monthly dinner meeting held in Los Angeles, April 14. The dinner was preceded by a business meeting presided over by Henry W. Pullman, president of the Chapter.

T. M. Johnston, master of ceremonies for the evening, introduced the first speaker, Dr. Elmer S. Nelson, who talked on "Price Control and Post-War Economics." Dr. Nelson was appointed by President Wilson as economic advisor to the government in 1918 and since that time has served on the War Trade Board, War Industries Board, U. S. Food Administration, and U. S. Shipping Board. Later he was professor of economics at the University of California and is now on the staff of the O.P.A. in California.

Great interest was shown in an address by Dr. E. B. L. Cunningham on "Our Enemies the Japanese." This speaker was well qualified to discuss the Japanese as he practiced medicine for many years in Tokyo and has lived both in Japan and China. At one time he was chairman of the American Committee of The Merchants' Association of Tokyo and was one of the founders of The American Club there. At present he is president and director of the Lewellyn Biological Institute.

There were many visitors at the meeting from all parts of the United States as well as from foreign countries. Among these were Chester Naramore, assistant secretary of the A.I.M.E. from New York; Al Dill of the New York Chapter of Nomads, and C. E. Whitney of the Houston Chapter. The guests from foreign countries included Ernest H. Smith of Casoc from Arabia; Harry S. Condor from Trinidad; C. C. Sutton of Caribbean Petroleum Company, Maracaibo, Venezuela, and Chet Cassel, formerly with The Texas Company in Venezuela.

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With REILLY PIPE ENAMEL

Booklet describing REILLY *Protective Coatings will be sent on request.*

Pipe lines coated with REILLY ENAMEL give long and dependable service and low maintenance costs in all types of soil and under wide extremes of temperature. The tough, durable REILLY coating effectually prevents corrosion from moisture, electrolysis, soil acids and alkalies; resists abrasion and soil stress, and will not crack in sub-zero cold or sag in tropical heat. . . . As an inner lining on water mains, REILLY ENAMEL protects against incrustations and tuberculation and assures full-capacity flow for the life of the pipe. . . . On storage tanks, structural steel work and other metal surfaces REILLY Coal Tar Paints give effective, economical protection against corrosive vapors and gases.

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SEVENTEEN · PLANTS · TO · SERVE · YOU

Continental Oil Makes Personnel Changes

Appointment of W. C. MacMillan to be manager of Continental Oil Company's Production and Drilling Department east of the Rocky Mountains is announced by President Dan Moran. He succeeds J. G. Dyer, vice-president, who resigned effective May 1 to join a Denver oil producing company.

W. C. MacMILLAN

Simultaneous with McMillan's appointment came the announcement that W. L. Kygar and R. W. French have been named assistant managers of the Production and Drilling Department. Kygar was formerly assistant to Dyer, and French has been production engineer for Continental's California division, with headquarters in Los Angeles. M. H. Shanahan, who has been assistant manager of the department, will continue in that post.

MacMillan, formerly manager of Continental's northern region of the Land Department, is succeeded by W. E. Haggard, who has been manager of the southern region of the Land Department, with headquarters at Houston, Texas. A. K. Tyson, who has been division geologist at Houston, has been named to replace Haggard.

Coincident with these changes the Oil Pipe Line and Terminal Division, the Telephone and Telegraph Division, and the Oil Trading Division, have been designated as the Pipe Line Department, with A. C. Wilkinson as manager. D. W. Sims, formerly superintendent of the Telephone and Telegraph Division, has been appointed assistant manager. T. A. Van Griethuysen, formerly superintendent of the Oil Trading Division, is now assistant manager in charge of oil trading.

Bantam Bearings Now Division Torrington Co.

Bantam Bearings Corporation, South Bend, Indiana, a subsidiary of The Torrington Company of Torrington, Connecticut, for the last eight years, has been merged with its parent company and will henceforth be known as The Torrington Company, Bantam Bearings Division. The Bantam Division will retain its present personnel and continue its operations from the South Bend headquarters.

C. H. Talcott, sales manager of The Torrington Company's Bearing Division, will continue to direct sales of the Torrington needle bearing. Ray Nichols, vice-president and general manager of Bantam, will be in charge of the Bantam Division's operations, and sales of needle rollers, Quill bearings, and other standard and special bearings will be continued under the direction of J. F. Oehlhoffen, sales manager of the Bantam Division.

Carter Oil Observes 50th Anniversary

The Carter Oil Company, Tulsa, Oklahoma, founded in 1893 in Sistersville, West Virginia, by Colonel John J. Carter, of Titusville, Pennsylvania, to operate properties he had purchased in the Sistersville field, completed 50 years on May 1 as a producer of crude petroleum. Its half century of service parallels that era of American progress during which the oil industry has grown from a relatively unimportant beginning into an indispensable asset, now importantly aiding in the struggle we are waging for Freedom's preservation.

COL. CARTER

The founder was born in Westport, County Mayo, Ireland, in 1842; came to America at the age of four; attended Nunda Literary Institute at Nunda, New York, enlisted in the Union army as a private at the outbreak of the Civil War in 1861, attaining the rank of lieutenant colonel before his discharge four years later; was cited with the Congressional Medal of Honor for "Most Distinguished Gallantry in Action" in the Battle of Antietam; entered the mercantile business in Titusville, Pennsylvania, in 1865; became an oil operator in the Bradford, Pennsylvania, field in 1877; organized The Carter Oil Company at Sistersville in 1893, and continued as president of the company until his retirement in 1915, two years prior to his death.

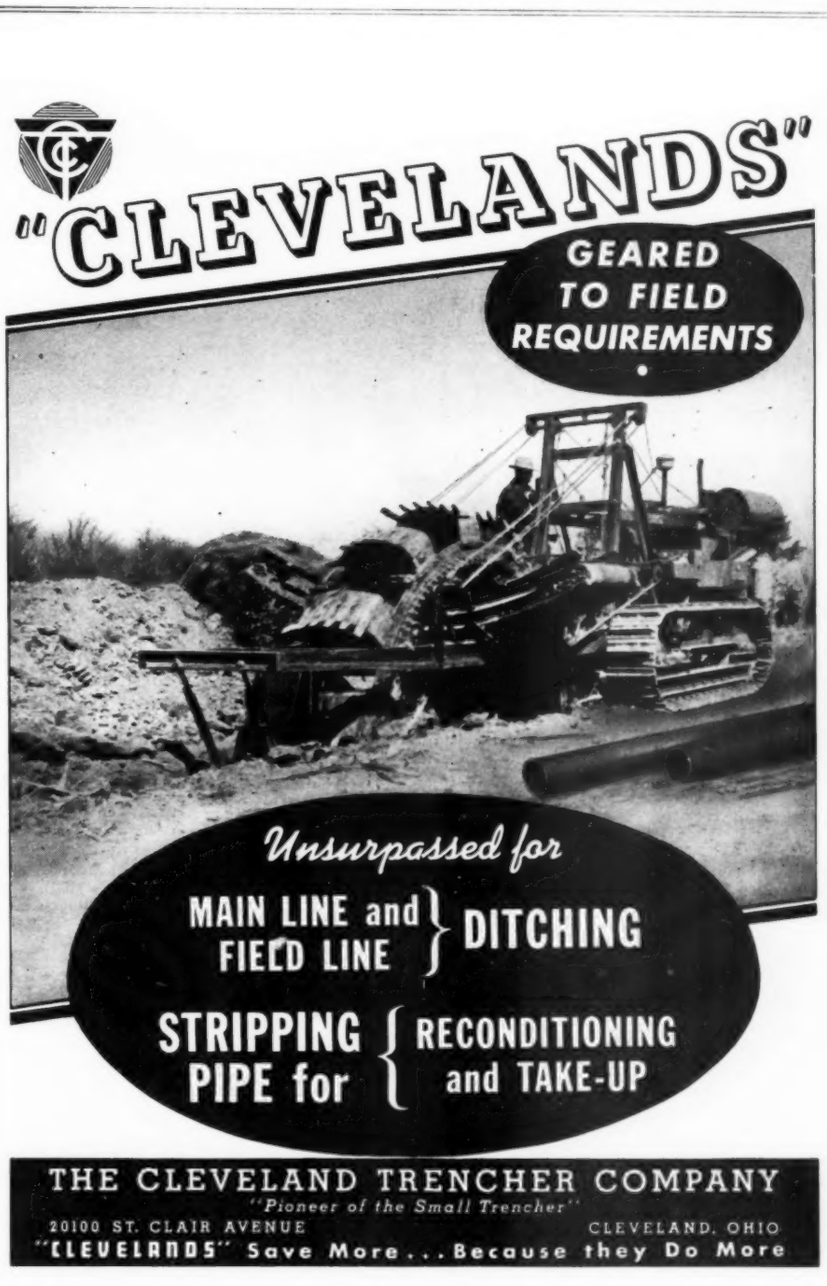
Toward the end of 1893, controlling interest in The Carter Oil Company was acquired from Colonel Carter by the South Penn Oil Company, a subsidiary of what was later to be known as Standard Oil Company (New Jersey).

Successful from its inception, The Carter Oil Company expanded westward to the Mid-Continent with the industry in the early days of the twentieth century, establishing headquarters at Tulsa, Oklahoma.

Lufkin Rule Awarded Army-Navy "E"

The Lufkin Rule Company, Saginaw, Michigan, has been awarded the "E" for excellence in the production of war material. This is the Army-Navy joint recognition of high achievement and exceptional performance, both as to quality and quantity production of tools indispensable to the war effort. It is an acknowledgment also of the meeting or bettering of shipping schedules, the maintenance of fair labor standards and efficient management.

Practically every article in the present Lufkin line is used in war work, many of them very extensively.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GEARED TO FIELD REQUIREMENTS
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"CLEVELANDS" Save More...Because they Do More

ATTACK and DEFEAT
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SAND-BANUM
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"The Entirely Different Boiler and Engine Treatment"

Regardless of water or operating conditions, and saves shutdowns and water analyses.

And — Guaranteed harmless to personnel and equipment.

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ARMSTRONG BROS.
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ARMSTRONG CHAIN TONGS have been engineered to overcome the weaknesses discovered in ordinary tongs. They are stronger, last longer and are more convenient.

Jaws are drop forged, with milled teeth, are heat-treated and extremely tough. They have inner lugs which increase the bearing on the bar and also prevent chains from jamming. Other strength features include forged handles, large hardened steel bolts, alloy steel shackles and proof-tested chains.

ARMSTRONG BROS. Tongs come in *all* standard types, each in *all* sizes.

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Carter Heads A.P.I. Southwestern District

D. V. Carter, Magnolia Petroleum Company, Dallas, Texas, was chosen chairman of the Southwestern District of American Petroleum Institute's Division of Production. Vice-Chairmen named at the meeting in Houston, Texas, were: Fred Shields, San Antonio, vision of Production. Vice-chairmen R. Kyner, Kilgore, vice-chairman for East Texas; J. H. House, Midland, Texas, for West Texas and New Mexico; C. F. Patterson, Wichita Falls, for North Texas; M. L. Euwer, Sulphur, for North Louisiana; V. J. Martzell, Shreveport, Louisiana, for North Louisiana and Arkansas, and George C. Card, Fort Worth, for North Central Texas. A. W. Baucum, Houston, is secretary-treasurer.

Knox New President Of Bucyrus-Erie

In a series of changes designed to give increasing responsibility to younger men, N. R. Knox was elected president of Bucyrus-Erie Company, South Milwaukee, Wisconsin, at a meeting of the board of directors.

N. R. KNOX

W. W. Coleman, company president for 32 years, was re-elected chairman of the board. George A. Morison, former vice-president, was elected vice-chairman of the board. W. L. Litle was elected vice-president, and will be in charge of the company's plants at Erie, Pennsylvania, and Evansville, Indiana. N. A. McGrath was re-elected secretary and J. G. Miller, treasurer.

Appointed officers now include W. M. Bager, technical director; D. P. Eells, vice-president with special assignments; P. H. Birckhead, vice-president in charge of the sales department; R. W. Newberry, vice-president in charge of the commercial department; C. K. Charlton, assistant to the president. The senior officers will continue to devote full time to the company's affairs, but the changes will give increasing responsibility to younger members of the organization.

Knox has been with the Bucyrus-Erie Company for 23 years. Upon leaving Harvard in 1920, he began work in the company's foundry as a special apprentice. He became vice-president in charge of manufacturing in 1933 and held that office until his recent election to the presidency.

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Don't wait — get this new Safety Lantern with BROKEN BULB EJECTOR!

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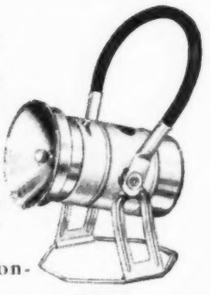

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- Sealed beam construction.
- Throws bright beam 1500 feet.
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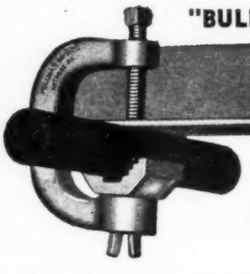
★FLOOR BOXES ★ WIRING SPECIALTIES★



"BULL DOG" PIPE OR CONDUIT HANGERS

Holds pipe with bull dog tenacity. Made of high-quality, malleable iron. Adaptable for such wide range of use that it makes itself a necessity in refineries, mills and factories. Saddle turns for pipe to run parallel or at angles to beam.

INSULATOR SUPPORT WITH HANGER ATTACHED TO CONDUIT

Furnished complete with stove bolts and machine screws for attaching Hangers to Insulator Supports.

Jobbers' Inquiries Invited

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LATROBE . . . PENNSYLVANIA

Ensign W. E. Schlueter Killed in Plane Crash

Ensign W. E. Schlueter, 26, son of W. A. Schlueter, owner of the Refinery Supply Company, Tulsa, Oklahoma, and Mrs. Schlueter, was the victim of a navy plane crash near Nags Head, North Carolina, April 10. His body was returned to Tulsa for burial. Ensign Schlueter was a graduate of the

ENSIGN SCHLUETER

University of Missouri, going from there into his father's company. He was manager of the Refinery Supply Company offices at Houston, Texas, when he became interested in flying. With the advent of war Schlueter joined the Navy and received his wings at Corpus Christi in October, 1942.

Climax Engineering Buys McAlear Company

Ownership of McAlear Manufacturing Company, Chicago, Illinois, producer of valves, regulating and control equipment, was acquired by the interests controlling Climax Engineering Company, manufacturer of internal-combustion engines, power units, and generating sets, it is disclosed from the Climax home office in Clinton, Iowa.

Edward F. Deacon, Climax president, also will be president and general manager of the McAlear company, it was stated in an announcement jointly issued by Deacon and Owen L. Coon, chairman of the board of General Finance Corporation, of which both companies are now subsidiaries. Mrs. P. G. McAlear, formerly president and now chairman of the board of the McAlear company, will continue to be actively identified with the management.

Products manufactured by McAlear are widely used in the same fields served by Climax. In that connection Deacon expressed the opinion that this move would help both companies to broaden their service to customers in the oil industry and in the industrial and export fields.

UNRETOUCHED PHOTOGRAPH OF

SCALE DEPOSIT IN 12-INCH STEAM LINE

The picture of this scale deposit was taken from a point in the header 400 feet from the boilers. This scale seriously impaired the efficiency of this plant.

The solution to this problem is Haering Glucosates which remove the scale and protect pipe lines from further scale and corrosion.

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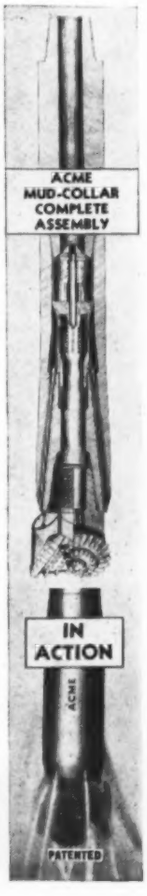
There are few Mud Collars in stock. You know the difficulties of obtaining *critical materials*. And, too, Acme is now in war production. So, don't delay placing your Mud Collar order—as deliveries from *new stock* cannot be promised for "the duration."

Here's what Acme's Mud Collar can do for you—as proven by satisfied users—in any formation:

It lessens drill pipe torque; assures faster, easier cutting, longer runs, fewer "green bits" and makes better hole. . . . Its 6 high-velocity fluid streams keep cutters clean, bit bearings "lubricated" and free of cuttings—while constantly flushing bottom. . . . In sticky formation, it also prevents mud rings and "balled up" bits.

Decrease material purchases by increasing the life of bits and drill pipe. Learn how—with this "wonder tool." Write TODAY for full information. *And don't delay your order.*

(Also ask for Catalog No. 12. It gives valuable information on correct use and care of Acme cable tools.)



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All Wisconsin Air-Cooled Engines are equipped with an exceptionally rugged, oversize crankshaft (as compared with other engines of comparable size)...drop-forged for maximum molecular compactness and ability to withstand the terrific pounding to which this vital unit is subjected in heavy-duty service.

Because the burden of heavy-duty engine operation falls on the crankshaft, we feel that no crankshaft can be made "too good". We build them as good as we know how.

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MECHANICAL OR PROCESS ENGINEER

Want mechanical or process engineer who is experienced in *equipment* or *calculations* used in the CHEMICAL OR MANUFACTURED GAS INDUSTRIES—such as washers, gas holders, pumps, instruments, furnaces; or heat balance, absorption, water gas generation, gas handling, etc.

Good salary, permanent position, excellent future. Give full details of experience, education, personal data. Address . . .

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GAS PROCESSES DIVISION

224 East Broadway **Louisville, Kentucky**

Book Reviews

Compressed Air Data, edited by F. W. O'Neil. Published by Compressed Air Magazine. Pages, 308. Price, $3.

The fifth edition of "Compressed Air Data" was copyrighted in 1939. It retains the essential features of the preceding editions and considerable new data. Many of the curves have been redrawn in accordance with recent changes and considerable information has been included on the compression and transmission of gas, which is closely allied to the air compression field. It is a comprehensive and carefully edited handbook of pneumatic engineering practice.

•

An Index to American Petroleum Statistics. Issued by Special Libraries Association, 31 East Tenth Street, New York. Price, 50 cents plus 3 cents postage.

A subject guide to petroleum statistics, the index was compiled by Bradford A. Osborne, head of the technical department of the public library, Tulsa, Oklahoma. The 14 pp. of mimeographed references contains a list of 42 publications that carry data in connection with the petroleum industry.

Ladish Drop Forge Company Given Army-Navy "E" Award

The Army-Navy "E" Production Award has been presented to the men and women of Ladish Drop Forge Company.

The short, business-like presentation ceremony was made in the plant. Victor F. Braun, president of the company, made the address of welcome. The presentation address was given by Lt. Col. Edward H. Bowman of the U. S. Army Air Corps,

Left to right: Lt. Col. Edward H. Bowman, U. S. Army Air Corps; Herman W. Ladish, chairman of the Ladish board of directors; Otto Retzloff, employee representative; Captain D. D. Dupre, Commandant, Naval Officers Training Corps, Marquette University

and the acceptance address by Herman W. Ladish, chairman of the Ladish board of directors. A token presentation of the individual Army-Navy "E" pins was made by Captain D. D. Dupre, commandant of the Naval Officers Training Corps at Marquette University, to Otto Retzloff, who accepted on behalf of the 3400 Ladish employees and struck a heart-warming note of confidence and determination in a stirring address of acceptance.

TRADE LITERATURE

What to Write For

VALVES ARE THE SUBJECT of a booklet issued by The Edward Valve and Manufacturing Company, 1592 West 145th Street, East Chicago, Illinois. Catalog No. 101, called "Edward Better Valves" includes a large cast- and forged-steel line, complete with illustrations, descriptions, and dimensional tables. Copies will be sent upon request.

A DETAILED DESCRIPTION of a new pneumatic transmitter for measuring flow and level has been published by Republic Flow Meters Company, 2234 Diversey Parkway, Chicago, Illinois. The transmitter operates on the force-balance principle, producing high accuracy and responsiveness, according to Bulletin No. 43-4, which will be sent upon request.

THE REFINERY SUPPLY COMPANY, 621 East Fourth Street, Tulsa, Oklahoma, has made available a bulletin on recording instruments. It carries descriptions and illustrations of testers and recording mechanisms.

A COMPREHENSIVE but condensed collection of fundamental engineering data has been published by Hyatt Bearing Division, General Motors Corporation, Harrison, New Jersey, under the title "Engineering Handbook." The book contains 96 pages of material that eliminates time-consuming calculations. The edition is limited and will be distributed only to engineers and designers of war products who can actively use it. Each request should state the position of the person who makes it.

BULLETIN 120D has been issued by American Air Filter Company, 384 Central Avenue, Louisville, Kentucky, on special type filters. Methods and kinds of air cleaners for varieties of power equipment are described.

TURBINE PUMP DATA, a 144-page book full of illustrations, performance curves, selection tables, installation, and operating information on turbine pumps, has been published by Dayton-Dowd Company, Quincy, Illinois. A free copy of this exhaustive study of turbine pump operation will be sent upon request.

"ELECTRIC DRILLING RIGS" is the title of a 58-page book issued by Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania. The brochure covers important facts on electric drilling rigs, illustrations of a-c. and d-c. equipment on the job, operating data, performance curves, rig floor plans, and other useful suggestions.

PUMPS and hydraulic equipment are discussed in a 16-page catalog showing representative pumps and hydraulic equipment for power plants, oil fields, process industries, and marine use. Description of the many types are given and their applications are listed. The Aldrich Pump Company, Allentown, Pennsylvania, will mail a copy to those who write for it.

A NEW 28-page booklet called "Organic Methods of Scale and Corrosion Control" is just off the press and is available to those sending requests to D. W. Haering and Company, 205 West Wacker Drive, Chicago, Illinois. This is the fifth edition of this text on the use of organic chemicals in water treating and it discusses the newest information on scale and corrosion control. A new section is introduced that tabulates the physical and chemical properties of various glucosates.

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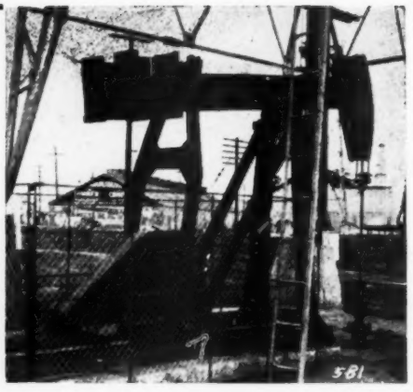

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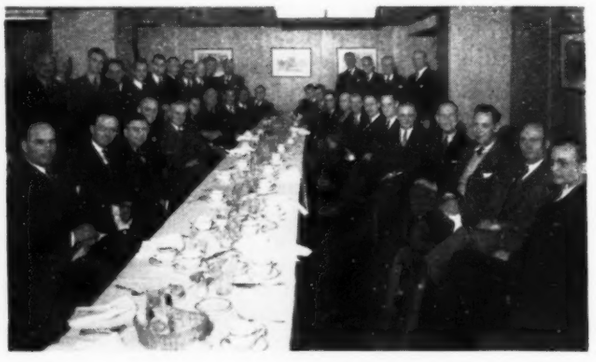
Superior Engine Sales Meeting Held

The annual sales meeting of the Superior Engine Division of the National Supply Company was held at the factory in Springfield, Ohio, recently. The meeting was directly in charge



of Arch F. Campbell, sales manager of the Superior Engine Division, under the supervision of A. W. McKinney, vice-president in charge of sales of the National Supply Company.

Link-Belt Elects O'Neil Vice-President

Link-Belt Company announces the elevation of Frank S. O'Neil, general manager of the company's Indianapolis operations, to the position of vice-president. Vice-president James S. Watson, Indianapolis, who has just rounded out 50 years of service, plans to retire at the end of this year from active duty. He continues as a director of the company.

O'Neil joined the Link-Belt organization at the company's Pershing Road plant in Chicago, where he worked in the foundry, machine shop, cost department, and rate setting and production departments. His Indianapolis plant experience dates back to 1916, the year he was transferred there from Chicago. In Indianapolis, he has served as assistant superintendent in charge of malleable iron chain assembly, superintendent of the Ewart plant, assistant general manager of Ewart and Dodge plants, and as general manager since 1939.

O'Neil's headquarters will continue to be at 220 South Belmont Avenue, Indianapolis, Indiana.

Executive Promotions by S.K.F Industries

Three executive promotions are announced by S. F. Wollmar, executive vice-president of S.K.F. Industries, Inc., Philadelphia, Pennsylvania.

Thomas W. Dinlocker was elected vice-president and treasurer, Richard H. DeMott, vice-president in charge of sales, and C. P. Collins, secretary. William L. Batt, vice-chairman of the War Production Board, retains the presidency.

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MEETINGS

American Petroleum Institute, Mid-Continent Section, Division of Production—May 20 and 21, Tulsa, Oklahoma.

Joint Production and Chemical Committee Conference sponsored by Technical Section of American Gas Association—May 24 and 25, Hotel Pennsylvania, New York.

Society of Automotive Engineers, Diesel Engine and Fuels and Lubricants Meeting—June 2 and 3, Carter Hotel, Cleveland, Ohio.

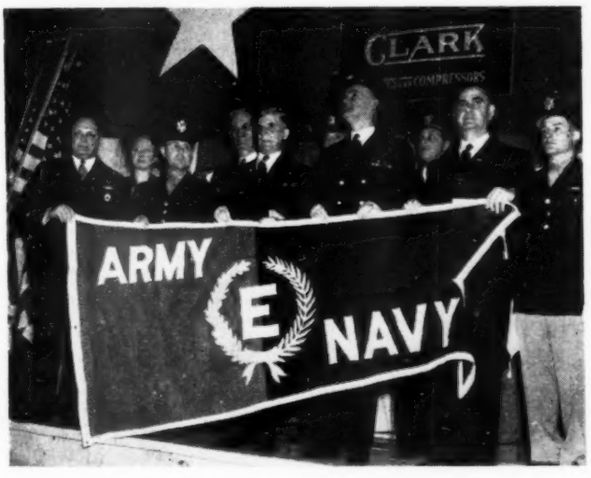
California Natural Gasoline Association, Monthly Meeting—June 3, Barker Bros. Auditorium, 818 West Seventh Street, Los Angeles, California.

Army-Navy "E" Award to Clark Bros.

For their "fine record in the production of war equipment," the Army-Navy "E" Award was conferred recently upon the men and women of Clark Bros. Co., Olean, New York.

The presentation ceremonies, held in the Olean Armory before an audience of 3500, were given unusual interest and impressiveness by the genius of John B. Kennedy, renowned radio and screen commentator, who presided.

Representing the Army, Lt. Col. Ernest W. Ogram paid tribute to the company for its quick and complete mobilization for the production of war equipment, and commended



Left to right: C. Paul Clark, president, Clark Bros. Co., Inc., Lt. Col. Ernest W. Ogram, John B. Kennedy, Com. R. G. Walling, and Stephen J. Rich, Sr.

the employees for the "excellent job done to date." Speaking for the Navy, Com. R. G. Walling charged all civilians with the duty of "seeing that our armed forces are supplied with the best equipment that can be made. That you at Clark Bros. Co. have not failed in your duty," he continued, "is shown by our being here today."

The "E" pennant was accepted on behalf of both management and employees by C. Paul Clark, president of the company. "E" Award pins were thereupon presented to Stephen Rich, Sr., Coletta E. Keeny, Timothy M. O'Brien, and Mr. Clark, acting as representatives of the entire organization. The ceremonies concluded with an address by Mr. Rich, president of the Employees Association, who accepted the pins on behalf of the employees with a promise that the men and women of Clark Bros. would continue in action "until the day Hitler's unconditional surrender comes."

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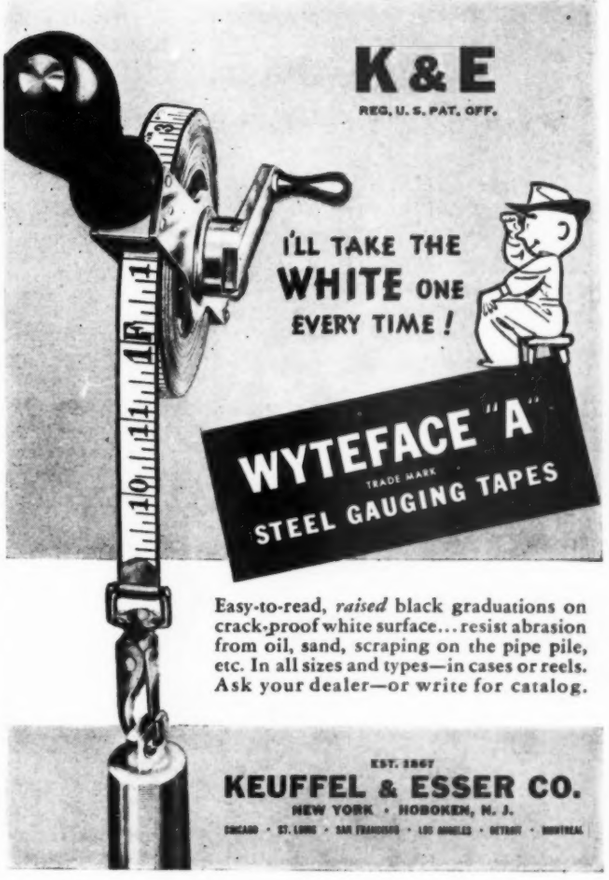
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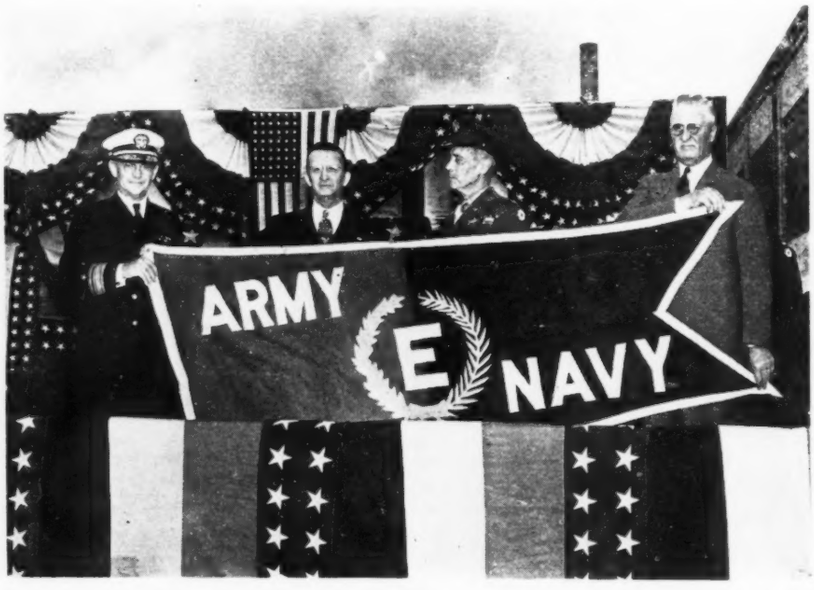
Oil-Industry Men in Chemical Warfare Service

The Chemical Warfare Service, Dallas Procurement District, numbers among its members numerous former oil-industry men, affiliated either with oil companies or equipment manufacturers. Sitting are: Major John F. Adams (left), Lieutenant Colonel Harold M. McCullough, Major William J. Briggle, and Major Jesse E. Hendricks. Standing: Captain Raymond G. Justen, Lieutenant Roy A. Lamb, Captain Albert Pranger, Captain Dan B. Courville, Captain Art I. Robinson, and Major William P. Stone.

(Photo by U. S. Army Signal Corps)

Beaumont Iron Works Wins Award

Officials and employees of the Beaumont Iron Works Company, Beaumont, Texas, recently joined in the ceremony in which the Army-Navy "E" award was presented for work well done. Rear Admiral P. W. Foote, U. S. N. retired, presented the pennant to A. I. Brainard, president of the firm. An address, praising the industry of the small machine shop only 33 years ago, was made by P. B. Doty, president of the First National Bank of Beaumont. "E" pins were given to all employees.



Army and Navy officials present "E" pennant to Beaumont Iron Works Company. Left to right: Rear Admiral P. W. Foote, U.S.N., retired; John W. Baer, veteran employee; Colonel Royden Williamson, U.S.A.; and A. I. Brainard, president, Beaumont Iron Works

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Now, as always, ENSIGN is unequaled for efficient and economical carburetion.

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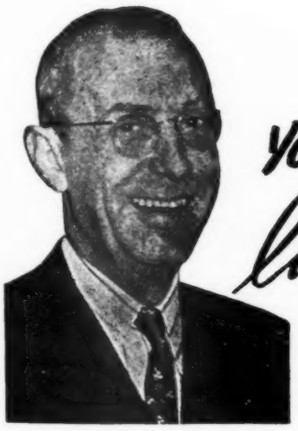
Prepare, NOW, for post-war demands. Our competent engineering staff is at your service.



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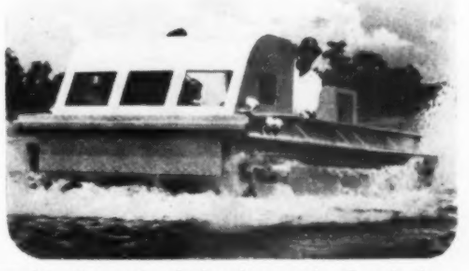

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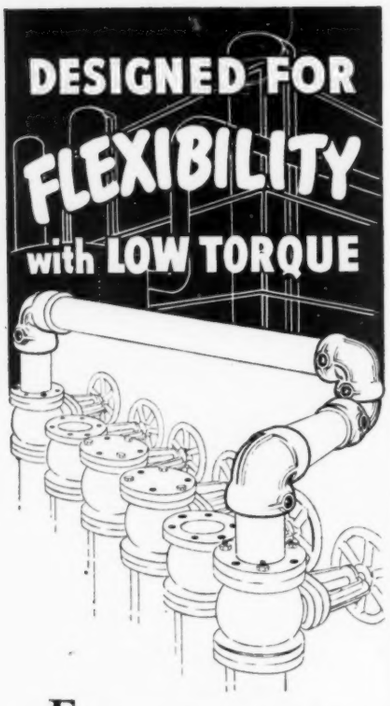

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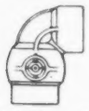
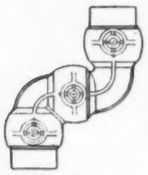


Style No. 30
1-way Swivel



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BREA, CALIFORNIA
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